POWER

Volume 50 New York, August 5, 1919 *Number* 6

Candid Chats

The Chief Should Lead

IN ALMOST every human body there is a lazy streak, an inclination at times to half do a thing, to hit it a lick and give it a promise, and the monotony of routine power plant work induces it in the personnel from top to bottom. If the chief, dressed in clean cool clothes, sitting in his office behind a 16-inch fan, issues an order to his immediate junior to burn down, die out and clean the boilers of one part of the battery, then turns his attention to other matters, he is surely exercising his prerogative as boss, but will he get good results? He emphatically will not. But if he dons his unionalls, cap and work gloves, goes out into the boiler room to direct his men, now and then actually taking hold of the work with his own hands, the men will go at their tasks with the same spirit evinced by their leader, and the work will be quickly and easily performed.

If the chief furnishes the initiative, the brains and the will power, the men will become imbued with his spirit and the work will swing along smoothly. Then the chief may slip away and give his attention to something else. But it is well to show up occasionally during the progress of the work, take hold of some of it and give it another push—not in a nagging way but by doing something that the men must do, such as trying the turbining of a few tubes with a few words to the fellow who is doing it—this sort of thing does a lot toward making the men feel that the chief is one of their kind.

Now, perhaps some will feel that their time is too valuable to waste in such a manner, using the idea that a good boss gets the others to do all the work. That does sound well, but it does not always work, and if plant morale amounts to anything, then leadership is the best developer of it. Chiefs who want to be good leaders of their men ought to size up about as follows:

Have a complete knowledge of all the work to be undertaken and the conviction of past experience. The men should never for a minute get the idea that their chief doesn't know his job.

Have a good knowledge of the men, their likes and dislikes, their interests and welfare.

A disposition to harmonize, for friction among men tends to delay the work and causes general discontent.

Always be open-minded enough to consider suggestions from even the humblest coal passer or engine wiper.

These suggestions, of course, are not necessarily questions of plant management, but your men will be favorably impressed if their ideas and suggestions on the minor things that come up every day are heeded. Men like to feel that they can use their heads to give you a pointer once in a while.

Intimacy with your men is not as detrimental as is the habit of aloofness. It is possible for a leader to make each one of his men feel as though he were a personal friend and still have him respect the position as chief. A word of praise now and then also helps wonderfully.

Reprimand your men when it is needed, but in such a way that no scar is left. If a man does not do as you tell him, or do it in the right way, ask yourself if by any chance he could have misunderstood you.

But if reprimand is needed, make it to the point, positive, and without heat, then give him a job that requires unusual responsibility and let him climb back into your good graces.

Contributed by Charles H. Willey

Making Three Boilers Do the Work of Five

By J. J. SPANGLER

By revamping a plant short of engine and boiler capacity, due to inefficient conditions, three boilers were made to do the work that five could scarcely handle, and a saving in coal estimated at 7000 tons per year was effected.

DURING the summer run of 1918 the Peerless Portland Cement Co., of Union City, Mich., had a hard time getting through its running season, which generally opens in March and continues to the end of the year. Most of the trouble was due to inefficient conditions in the power plant, which resulted in numerous shutdowns aggregating a total of 42 days during the season and causing a serious financial loss, as the capacity of the plant was 1600 bbl. of cement per day.

In the first place the load on the engines was so heavy that they could not handle it when running noncondensing. Condensers had been installed but were of the steam-driven, jet type, located several hundred feet from the power plant and 36 ft. below on the river bank. The condensing equipment was in bad shape and broke down frequently. At such times it was necessary to remove some of the load so that the engines could maintain normal speed. When the condensers were in service, the vacuum at the engines did not exceed 18 in. The live-steam lines leading to the condensers were uncovered, causing a great loss of steam, and this when the plant was short of boiler power to meet the demands under the inefficient conditions prevailing.

Contracting Engineer Called In

The need of engineering advice was recognized by the management. The first conference with a firm of consulting engineers resulted in a decision to install a barometric condenser. This, however, would not entirely relieve the situation, as additional boiler capacity would be needed. About this time H. J. Gebhardt, contracting engineer, of Chicago, was called into consultation by the management. After becoming familiar with the conditions he decided that changes in the condensing equipment that would eliminate the steam consumption at the river condenser house and improve the vacuum, and a better water supply from the boilers and a thorough overhauling of the engine room, would put the plant in such condition that it could easily care for the present demands without addition to the engine or boiler capacities. By Jan. 23 of this year a supervising engineer was on the job to carry out the remodeling considered necessary. It was desired to have the plant in operation by Mar. 1 if possible.

The first step was to tear out the jet condensers at the river and install near the plant a surface condenser having 3000 sq.ft. of surface. The next was to dig a receiving well at the river bank for the circulating water and at this point to install a centrifugal pump directly connected to a 30-hp. motor to furnish water for the condenser and the mill supply. The saving effected by the installation of this pumping unit will be realized when it is stated that it is to do the work previously cared for by a 13½ x 20 x 18-in. jet condensing outfit, another jet condenser with dimensions of 28 x 14 x 19¾ in. and two direct-acting steam pumps on the mill supply, one a 10 x 6 x 12-in. simplex, and the other a 14 x 8 x 14-in. duplex pump, all being steam-driven, while the present pump is motor-driven.

Changes in Exhaust-Steam Lines

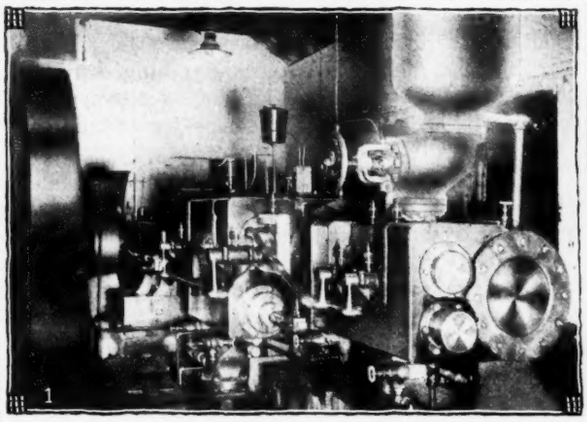
From the plant to the old condensing equipment there were two exhaust steam lines, one 10 in. in diameter and the other 15 in. Near the engine room these lines were severed and the plant ends of them used to convey the exhaust steam from the engines to the new surface condenser. The river ends of the lines were used to convey the circulating water from the pump at the river to the condenser and back again toward the river. The 10-in. line was connected to the pump discharge and the 15-in. line used as an overflow for the cooling water from the condenser. Between the condenser and the pumphouse at the river, a hotwell was excavated and the return water from the condenser discharged into it, the end of the pipe being submerged in the well so as to effect a water seal. As the well is about 25 ft. below the overflow at the condenser, the head on the circulating pump is reduced 10.85 lb., thus decreasing the current consumption of the motor driving the pump. From the hotwell the water overflows into another section of the 15-in. pipe and is discharged into the river downstream from the pump section.

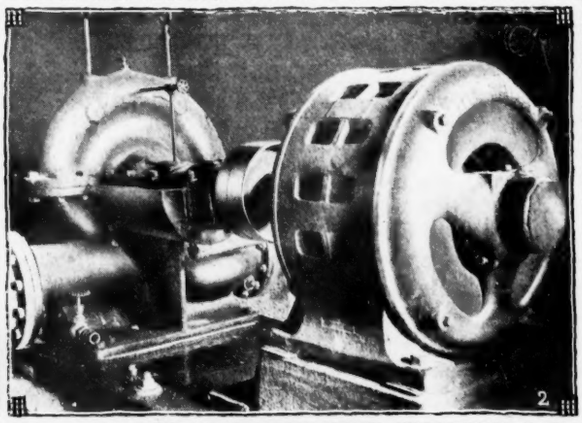
At the side of the river where the pump is located, the water is relatively low and in midsummer is apt to go dry. To insure a constant supply a canal of sheet piling was driven from the receiving well to the main channel of the river and the interior excavated to make an open channel for the water. At the entrance to the receiving well two screens have been provided, one of 1-in. mesh and the other of ½-in. mesh. Either can be removed for cleaning while the other remains in service.

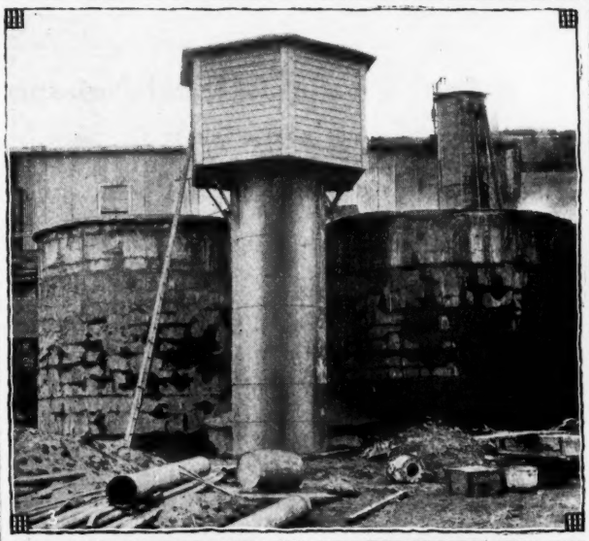
Water-Softening Plant Installed

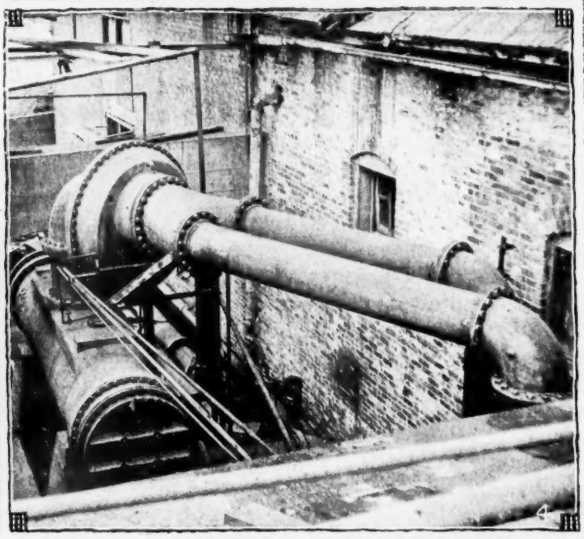
An analysis of the river water used for boiler-feed purposes showed that it contained between 17 and 19 deg. of hardness. In the past the boilers had scaled badly and there had been no end of trouble from tubes burning out and boiler-washing expense. Due to a number of small steam-driven units in various locations about the mill that exhausted to atmosphere, the amount of makeup water needed was a considerable proportion of the boiler feed even after the surface condenser was installed. Consequently, a water-softening plant was installed to care for the make-up. It was designed to reduce the hardness to 4 deg., although at times due to variations in the quantity of water and improper proportions of chemical, 8 deg. of hardness, or in other words, 8 gr. of scale-forming matter per gallon remained in the water. Even with this degree of softening there was a great improvement in operating conditions in the boiler room.

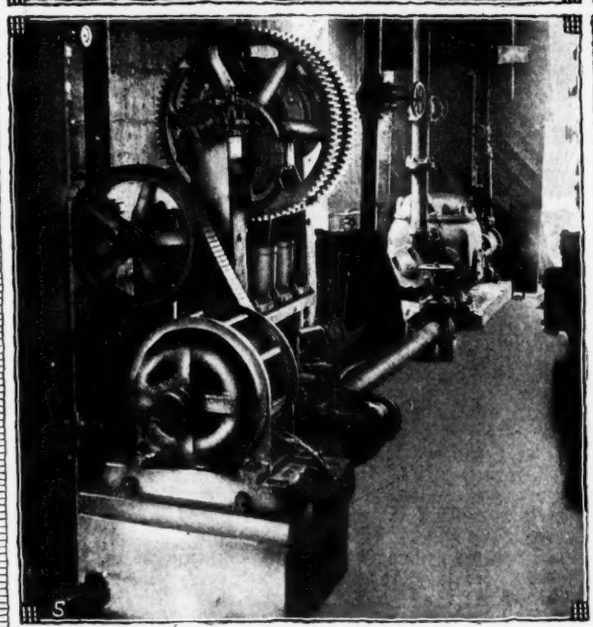
The boilers had been equipped with inclined-grate stokers arranged for the circulation of cooling water. Connections were made into the upper and lower drums of the Stirling boilers in the plant, and circulation de-











FIGS. 1 TO 6. SHOWING SOME OF THE CHANGES MADE IN THE PLANT OF THE PEERLESS PORTLAND CEMENT COMPANY

Fig. 1—Tandem compound cylinders placed on frame of simple engine. Fig. 2—Circulating pump at river. Fig. 3—Water-softening system and settling tanks. Fig. 4—New surface condenser installed adjacent to engine room. Fig. 5—Motor-driven triplex pump replacing direct-acting boiler-feed pump. Fig. 6—Extending intake to main channel of river.

pended on gravity. Owing to the formation of scale and intermittent operation, the cooling system did not prove effective, so that numerous grates were burned out. A great improvement was effected by installing a positive circulating system. The steam coils were removed from an old feed-water heater and the shell placed on the pumproom roof above the present feed-water heaters. Water from two big concrete settling tanks, forming part of the softener, was pumped to the grates and discharged to the open tank above the heater. The discharge to the tank was open so that from the boiler-room door the fireman could see that circulation through the grate was maintained. Under float control the water in the open tank flows by gravity to the feed-water heater.

All the condensate from the condenser is pumped into the settling tanks of the softener to raise the temperature to facilitate precipitation and in order that the boiler-feed water might be uniformly mixed. In passing through the grate the temperature of the circulating water is raised to 180 deg. F., so that the heater has comparatively little work to raise the temperature of the water to the usual 210 deg. On this account, even after eliminating the steam-driven equipment at the river, there was still more exhaust steam available than was required by the heater. Consequently, the steam-driven boiler-feed pump was replaced by a motor-driven triplex plunger pump, which in conjunction with the motor-driven pump at the river, takes current from the main generating units and thus uses steam at a better rate than did the direct-acting pumps formerly in use.

Changes Made in Engine Room

In the engine room there was need for considerable remodeling. A 22 x 36-in. piston-valve simple engine, directly connected to a 300-kw. generator, caused a great deal of trouble, as it was so heavily loaded that with a slight variation in steam pressure it would lose speed and in some cases drop the load. Besides it was extravagant in the use of steam, an unusually long cutoff being necessary to carry the load. The remedy was to remove the cylinder and attach to the same frame tandem-compound cylinders, measuring 18 x 34 x 36 in. The result was a more economical unit that would easily handle the load.

A tandem compound engine 18 x 30 x 42-in., driving the grinding mills through rope transmission, was also in bad shape. It had been running almost constantly for 16 years night and day, and because of so much dust and grit in the mill, the governor had become badly worn and sluggish. It would not respond quickly to variations in steam pressure or load, so that the speed regulation was bad. A new governor was installed, the valves reset and the engine given a general overhauling, with the result that it is now giving efficient service.

A third unit, consisting of a cross-compound Corliss, 18 x 36 x 48 in., operating at a speed of 97 r.p.m. and belted to a 400-kw. generator, had wrecked the high-pressure cylinder. This was replaced, and a general overhauling made the unit as good as new.

Boiler-Room Equipment

In the boiler room the equipment consisted of five boilers, one a horizontal Page-Burton sectional water-tube boiler rated at 350-hp., two 350-hp. and two 220-hp. Stirling boilers. All were equipped with the inclined-grate stokers previously mentioned. Feed-water regulators were installed and in the way of instruments, draft gages and a CO_2 recording outfit were provided. Two of the 350-hp. boilers were equipped with soot blowers, and later on it is the intention to install blowers in the other boilers. The coal-handling equipment consists of a bucket elevator and screw conveyors at right angles to each boiler. A steam-jet vacuum conveyor takes care of the ash.

After the changes enumerated had been made, it was found that the plant could be operated with three boilers as compared to the five previously used and an extra boiler contemplated. The greater part of the work was completed and the plant started up by Mar. 2. From results obtained, it has been estimated roughly that the saving in coal per season will amount to about 7000 tons, or, in round figures, a saving of about $30,000 per year. The plant is now in excellent condition and is good for many years of efficient service.

Steam Whistle as Legal Nuisance

Whether the owner of a steam-power plant is liable for injury caused by a horse taking fright on the blowing of a whistle at the plant must be determined according to whether any unreasonable noise has been caused under negligent circumstances. This is the test laid down by the Arkansas Supreme Court in the case of Daugherty vs. Southern Cotton Oil Co., 211 Southwestern Reporter, 179, in which it was decided that defendant was not liable for such an accident. The court makes this summary of the law on this point:

> The use of a steam whistle in a manufacturing establishment is not a nuisance in itself, but it may be so used as to become such. In the application of this principle it has been frequently held that, although it is lawful for a manufacturing establishment to maintain a steam whistle, that whistle must be used with ordinary care and due regard to the rights of others, and if, by the negligent use thereof, horses are frightened and caused to run away and inflict injury, the owner of the establishment is liable for the resultant damages. On the other hand, it may be said that the traveling public is entitled to make free use of the streets of the city, and that an adjoining property owner has no right to so use his property as unreasonably to interfere with the public enjoyment of this right. Still the doctrine is settled that it is not negligence in itself to own and operate near a public highway or street, a gin or other industrial plant in the necessary and reasonable operation of which loud noises are produced. . . .
>
> The use of the steam whistle in giving signals and for other necessary purposes in connection with operation of the plant becomes wrongful only when its use is attended with negligence. It is true that the horse became frightened at the sound of the steam whistle and ran away, throwing the occupants of the buggy with great violence upon a concrete sidewalk, and that he was a gentle and well-broken horse; but it will not do to say that, under these circumstances, defendant was guilty of negligence. If we should so hold that, because it was possible that a gentle and well-broken horse should become frightened at the noise of a steam whistle of the kind ordinarily in use when used in an ordinary manner, the effect of such holding would tend to prevent gins and other plants using steam from establishing and operating their plants in such places and thereby greatly retard the progress and development of the country.

But it is to be inferred from the opinion that liability will attach should a whistle be sounded under such unreasonable circumstances that the person blowing it should know of the likelihood of horses being driven nearby taking fright, as where an engineer sees a team being driven by his plant and yet gives a sudden and loud blast which prudence should prevent him from doing until the team has passed.

Installation and Use of Air Chambers

By H. D. FISHER

Pump makers and users seem pretty well agreed that reciprocating pumps should be provided with air chambers to ease the shocks due to the starting and stopping of the column of water in the pipe line with each stroke of the plungers, but in putting this into practice there seems to be no very general recognition of the most effective arrangement and not much provision for maintaining enough air in them to make them serve their purpose.

THE function of an air chamber is to provide an elastic cushion to absorb the energy of the column of water leaving the pump, which has attained a velocity higher than the average during the middle of the piston stroke, and to feed out this energy again to maintain the velocity of the water in the pipe beyond the air chamber more nearly uniform during the period at the end of the stroke when the piston stops. To accomplish this most effectively, the air chamber should be arranged so that the moving stream of water flows directly into its lower end or is so guided into it that little energy will be lost by the eddying and disturbed flow of water making a sharp, unguided turn or attempting to return upon itself. It must not be lost sight of that it is just as much the function of the air chamber to feed out the energy absorbed and thus maintain a reasonably uniform flow as it is to absorb the shock in the first place. A water gage should always be installed so that it is known there is air in the air chamber.

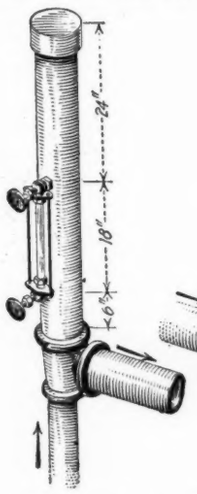


FIG. 1. AIR CHAMBER

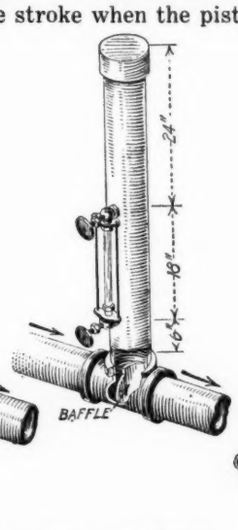


FIG. 2. BAFFLE IN TEE

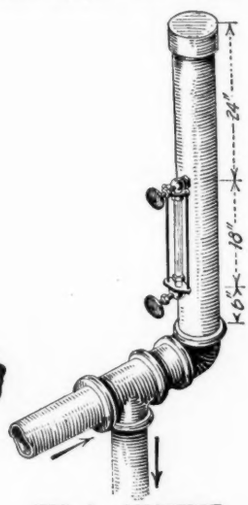


FIG. 3. ANOTHER ARRANGEMENT

The illustrations show arrangements suitable to various locations, all of which will work satisfactorily, as has been proved in many installations. Of these, Fig. 1, where a riser turns into a horizontal run is probably the most desirable as it requires fewest fittings, these are all standard and in it the air column meets the flow most directly. Equally effective is that shown in Fig. 2, for use in horizontal runs. Many similar air chambers have been condemned because the baffle to direct the stream upward has been omitted. The baffle need not fit water-tight, but should fit reasonably close and be firmly fastened by welding or screwed clips, as in long lines the pressure against it is considerable.

Arrangements shown in Figs. 3 and 4, where a horizontal line turns sideways or downward, are also good, but that shown in Fig. 5 should not be installed except where there is a supply of compressed air available for filling.

The best results are obtained by making the air chamber of the same size pipe as the feed line and obtaining the necessary volume by increasing its length. If it is made either larger or smaller, there will be an abrupt change of velocity in the water entering or leaving the air chamber, with a corresponding loss of energy and efficiency. For the average plant the dimensions shown on the sketches are ample, but for very long lines, such as occur in pumping plants. etc., the height should be considerably increased.

But no matter how well located the air chamber is, it must contain sufficient air to provide a cushion, and in plants where no supply of compressed air at or above boiler pressure is available this is often difficult to maintain, as the solvent power of water for air increases directly with the pressure. For instance, at 150 lb. it will dissolve eleven times what it would in an open tank, and any air in the air chamber rapidly disappears. Under such conditions it is customary to use the feed pump as a compressor, where the suction pressure is not too high, opening the water-cylinder drain-cock on the suction stroke, or with an open heater lowering the water level during a light-load period so that the pump sucks some air.

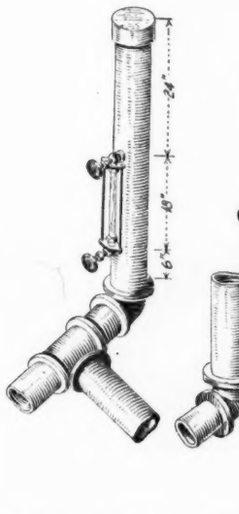


FIG. 4. A GOOD ARRANGEMENT

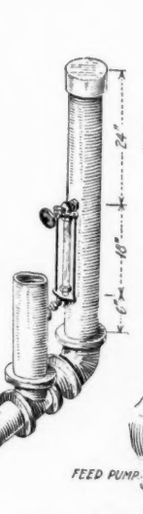


FIG. 5. REQUIRES COMPRESSED AIR

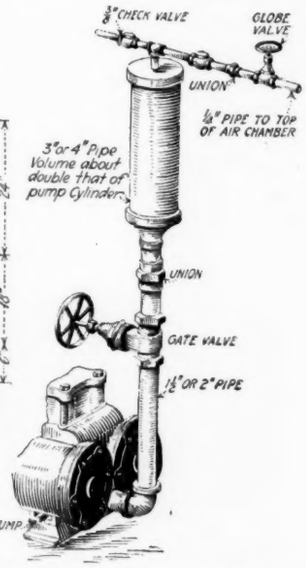


FIG. 6. HOW AIR IS SUPPLIED

A slightly more elaborate but effective arrangement, devised by Mr. Merriam, master mechanic at the Methuen Co., Methuen, Mass., is shown in Fig. 6. This also has the advantage that by throttling the valve it can be arranged to deliver just the quantity of air

required and will work indefinitely without attention. By means of the unions it could be quickly removed for the purpose of making repairs to the pump or for packing pistons.

It is in only very long lines, where the weight of the moving column of water is such as to cause severe shocks or where pumps are in very bad condition and give a similar effect, due to reversed flow, that the need of air chambers is forcibly impressed on the operating engineer. They are, however, advisable under all circumstances and particularly where it is desired to measure flow by means of orifice, venturi or pitot-tube meters, as, by reason of the natural laws on which they work, pulsating flow will cause all of them to read high by varying amounts.

In all these meters the pressure difference which operates the recorder mechanism is proportional to the square of the rate of flow; that is, if the flow is doubled, the pressure difference operating the recorder increases four times. Owing to inertia of the meter mechanism and friction and inertia of the water in the recorder connecting pipes, the meter acts like a throttled gage and shows a fairly steady reading, this reading corresponding to the average of all the differences of pressure corresponding to the flow at each instant.

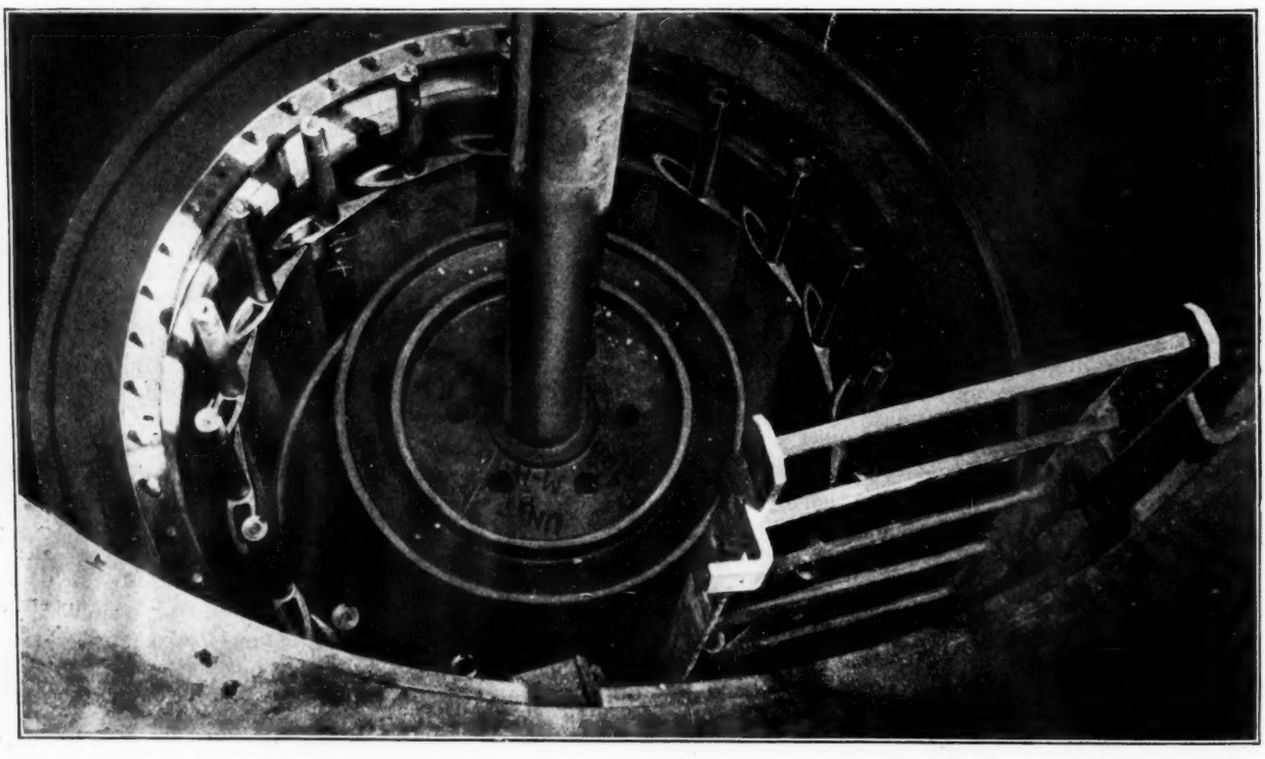
But in a situation of this kind the higher rates of flow will have a great deal more than their proper share of influence on the averages as what is being averaged is not the flows but the pressure difference produced by them, which increases very much faster than the rate of flow. For example, if for half the time the flow were 5 ft. per sec. producing a pressure difference of 2 in. of mercury and half the time 10 ft. per sec. with a pressure difference of 8 in. of mercury, then the average flow during the period would be 7.5 ft. per sec., but the average pressure difference acting on the recorder would be 5 in. of mercury, which would give a reading of 5 ft. per sec., or about 5.5 per cent. high. If the flow were nothing half the time and 15 ft. per sec. half the time, giving the same average of 7.5, the average pressure difference would be 9 in. of mercury and the recorder would read 10.6 ft. per sec., or 41.4 per cent. high.

Thus it will be seen that the wider the variation in rate of flow the greater will be the error of the rate of flow meter unless proper air chambers are provided to reduce the pulsations and produce a reasonably steady flow.

Reducing the fluctuations in flow by means of an air chamber is the only correct solution for problems of this kind. While experiments could be made and the meters calibrated to correspond to the conditions found, yet if the load or particularly the condition of the pump and valves changed, so that, for example, there was a slightly reversed flow, due to a defective valve on one pump stroke, this effect and its correction, which may very properly be called its pulsation factor, would be entirely different and require recalibration of the meter, while if proper air chambers are installed and it is seen that these are kept filled with air, the original meter calibration may be relied on and may be checked against steady flow at any time.

Early in September, patrons of the Kansas City Light and Power Company will receive their first current from a new $7,000,000 power plant which is now being completed in that city. It will be equipped with three 33,000-hp. turbo-generators.

Looking Down on the Wicker Gates of the Turbine of an Exciter Unit



The young man starting in a hydro-electric plant, and the engineer who desires to become acquainted with hydraulic turbines, like first of all to know, "how the thing looks inside." This picture so well shows the arrangement of the wicker gates of a hydraulic turbine that such men will be pleased to see it.

Needed Information on Refrigerants

By John E. Starr*

The consulting or designing engineer is as a rule a busy man. He is not expected in every case to go back to original and basic figures in thermodynamics. As a rule he goes no further than well-established tables of the properties of the working fluid he is dealing with.

No man in figuring a steam problem would, as a rule, spend the time and thought necessary to traverse plowed ground and figure, *a priora*, the latent heat, volume, heat of liquid, etc., of steam, nor would it be expected of him. He would pick up his Marks and Davis, Peabody or Kent or some other standard book containing steam tables and find at a glance, already figured for him, the required data.

The engineer has a right to rely on these tabulations. A reliance on standard tables in the case of steam is perhaps absolutely safe, but unfortunately, in the case of many other common fluids it is as yet far from safe.

Since the valuable contributions of Goodenough and Mosher, Keyes and Brownlee and the United States Bureau of Standards, and through the efforts of the American Society of Refrigerating Engineers, the figures on the physical properties of ammonia are now available, and there is so little difference in the tabulated figures that almost any reasonably up-to-date set of them will agree close enough for practical estimate or design.

This is not the case with many other fluids in daily use. Tabulations on chloride of methyl are published showing some variations. Sulphur-dioxide tabulation is fairly good, although Le Doux, Zeumer, and Denton and Jacobus differ slightly all the way through, although their little differences are more academic than practical.

Probably not more than four people in this country have the full data as to chloride of ethyl (a commonly used fluid) and these are from figures produced by Dr. K. Ohnes, of Leyden University, based on the results of work by Regnault and Gierre, and the previous calculations of Claperyon, Clausius and Selon and translated and extended by Starr.

The growing importance of CO_2, or carbon dioxide, as a fluid used in refrigeration brings the attention sharply to the subject. Designs make a calculation based on the tables authoritatively published vary so greatly that their use is extremely embarrassing.

Suppose a man is figuring on this fluid (CO_2) and picks up a table of Professor Schroeter such as is widely published in a half dozen compends and numberless catalogs of refrigerating machinery. For the sake of giving a definite example, say, he is figuring from —4 deg. F. to +77 deg. F., a common range of temperature between temperature sought and cooling water available.

He will find for —4 deg. a pressure of 292 lb. abs., a latent heat of 126.79 B.t.u., a volume of 0.3065 cu.ft. per lb. (3.265 lb. per cu.ft.) and heat of the liquid below 32 deg. of 26.91. For 77 deg. he finds a pressure of 938 lb. and a heat of liquid of 57.06 above 32 deg. F.

Relying on this, he figures the heat of liquid as a total of —26.91 + 57.06, or 83.97. He then quickly solves $\frac{200}{126.79 - 83.97}$ and find he needs 4.67 lb. to the ton ex. cylinder heat and clearance 4.67 × 0.3065 equals 1.43155 cu.ft. per ton for displacement without practical allowances.

Suppose he had picked up Mollier or the result of a combination of Amagat and Mollier, widely published and notably repeated by Macintyre, p. 102, 1914: He would first find the pressures were given 288.7 lb. and 930 lb. instead of 292 lb. and 968 lb. This would not matter much as the mean pressure would come out pretty close. But he finds for the heat of vaporazation 118.87 B.t.u. heat of liquid — 17.87 for —4 deg. F. and +33.19 for 77 deg. and a volume of 0.313 cu.ft. per pound.

The final calculation is: $\frac{200}{118.87 - (+ 17.87 + 33.19} \times 0.313 = 0.92335$ cu.ft. per ton without allowance, instead of 1.42829.

The first calculation therefore (based on Schroeter) calls for a compressor 54.6 per cent. larger at the same speed than a compressor called for by Amagat and Mollier. At other ranges of temperature similar discrepancies occur, some smaller and some larger. But 54.6 per cent. is altogether too great for comfort. An examination of the figures shows the horsepower per pound to be only slightly different. But the horsepower per ton is of course different as in one case it would figure: 1.42829 × m.e.p. × 144 = ft.-lb. per ton, and in the other, 0.92335 × m.e.p. × 144 = ft.lb. per ton. There is still a difference of 54.6 per cent. in horsepower per ton.

Capacity might be remedied by change of speed, but horsepower per ton could not be if the wrong table were used.

Amagat and Mollier are perhaps nearer right, but it is not the purpose here to discuss the correctness of the tables, but only to show that there is a wide divergence. In either case, if the wrong tabulation was adopted, a contract would fail on horsepower per ton, and perhaps capacity might fail because arrangements made for speed might have been unalterable. In any event results as to capacity at a given speed would fail if the wrong table was taken.

There is also lacking in the case of CO_2 complete tabulation of the superheated gas at ordinary condenser temperatures. In this country the cooling water is on the average much higher in temperature than in Europe; so high, in fact, as to give condensing temperatures rather close to the critical temperature of CO_2, variously stated to be from 88.43 deg. F. to 88.6 deg. F.

We have tables of the superheat of ammonia carefully worked out and mathematically correct, but little used practically, because the critical temperature of ammonia (273.2 deg. F.) is so far above any normal condenser conditions that it seldom enters into calculations.

With CO_2, however, 88.6 deg. has to be reckoned with and there are no practical data that can be depended upon after we reach this plane in the condenser.

Mention is made in a vague way of the falling off of refrigerating work with CO_2 or the increase of horsepower per ton when the critical temperature in the condenser is passed, but little of a practical or even theoretical nature has been adduced.

Someone, perhaps the United States Bureau of Standards, should settle this matter for all time.

*Consulting Engineer, New York City.

Cores and Coils for Transformers—I

By ARTHUR PALME
Engineer, Transformer Engineering Department, General Electric Company

The structural details of various types of transformer cores are considered. A second article will describe the various windings used in modern transformer practice.

ARTHUR PALME

AN ELECTRICAL transformer is a stationary piece of apparatus designed to change the electric pressure or voltage of a circuit. This change may be either an increase or a decrease of voltage (step-up or step-down transformer). The change is made by electromagnetic induction, which necessitates a steadily fluctuating magnetic field, and is therefore possible on alternating-current circuits only. The reason for the use of a transformer lies in the fact that it is much more economical to transmit electric power over a long distance at a higher voltage than electric generators can produce.

It may be considered the upper limit to insulate a generator for 13,200 volts operating voltage. Yet, with this voltage only a relatively small amount of power can be transmitted but a few miles without undue losses. Raising the pressure makes possible the covering of long distances and the transmission of large amounts of energy with reasonable cross-sections of conductors. Using a voltage of more than 100,000 volts enables economical transmission of many thousand horsepower over more than 300 miles. Of course at the other end of the transmission line one or more stepdown transformers have to be installed in order to reduce the voltage again to an amount that can be safely taken care of in motors or other power consuming devices (see Fig. 1). At first glance it would appear a wasteful undertaking to employ a double transformation. However, a transformer is a stationary machine with no moving parts, and requires very little attention. Furthermore, the efficiency of a modern transformer is, depending upon its size, usually from 96 to 99 per cent., so that it causes very small losses. Transformers can be built absolutely weatherproof for unprotected outdoor installation; it is therefore not essential to provide space for these machines within the power house or substation.

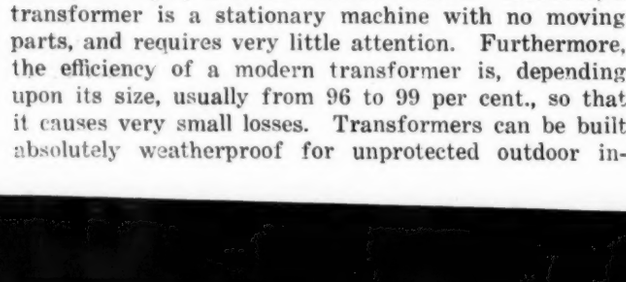
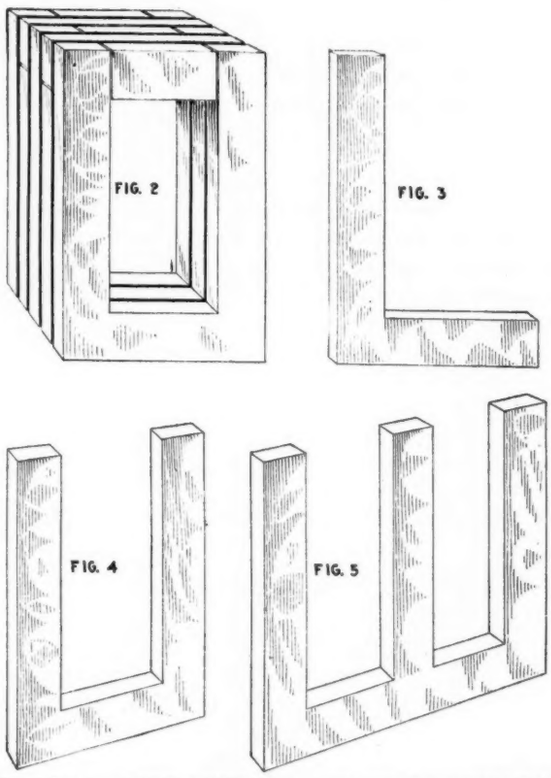


FIG. 1. DIAGRAM OF CONNECTIONS FOR ELECTRICAL-POWER TRANSMISSION

Every transformer consists mainly of two distinct electrical windings wound on an iron core. The two windings, called primary and secondary, are carefully insulated electrically from each other and the core, but are coupled magnetically through the iron core.

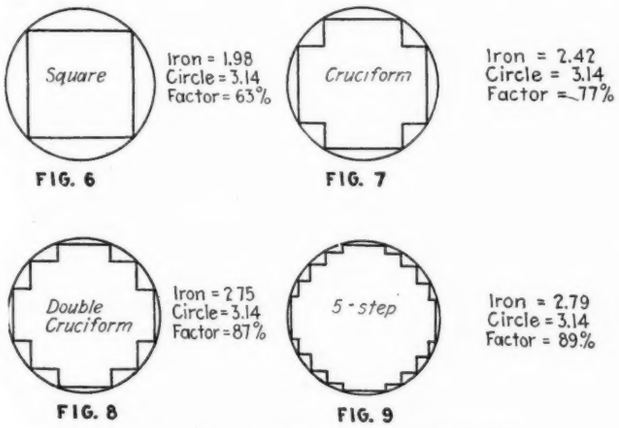
In order to obtain a transformation as efficient as possible, it is necessary that, as nearly as may be, all the magnetic flux set up by the primary windings shall enter the secondary windings. In other words, it is essential to avoid magnetic leakage. Aside from the number shape and the arrangement of the coils, the magnetic leakage is largely controlled by the iron core of a transformer.



FIGS. 2 TO 5. CORE ASSEMBLY AND CORE LAMINATIONS: THICKNESS GREATLY ENLARGED

Every winding that carries alternating current produces a fluctuating magnetic field, the main axis of which is parallel to the axis of the winding. In any metallic mass that is brought within this field will be set up so-called eddy currents, which will quickly cause a heating of this metallic body. This fact can be easily demonstrated by holding a pair of pliers or any other substantial piece of metal within a small coil connected to an alternating-current supply. The metal will soon get so hot as to burn the hand. For this reason iron cores used on transformers cannot be made up of a solid piece of iron, but must be subdivided in such small parts as to make the eddy currents negligible. It is general practice to build up transformer cores from thin

sheet-steel pieces punched or sheared in the proper shape. As the frequency of the alternating current determines the value of eddy currents, the thickness of the core punchings is made approximately 14 mils for all 60-cycle transformers, and 25 mils for 25-cycle cores (0.014 in. and 0.025 in. respectively). For special transformers used on high-frequency work, such as



FIGS. 6 TO 9. CORE CROSS-SECTIONS

radio-transformers, much thinner sheets, down to a few mils, must be used, to prevent undue heating of the core.

The individual sheets making up the whole core must be electrically insulated from each other. This used to be done by stacking the steel sheets alternately with sheets of very thin tissue paper. At present, however, it is general practice to coat every punching on one side with a thin film of quick-drying special lacquer. The punchings are stacked so as to form the core and clamped together with bolts. Great pressure has to be used for this clamping, because loose core punchings will cause an objectionable humming noise, combined with more or less violent vibrations. To entirely prevent the humming does not seem to be possible; it is therefore an easy test to determine whether a transformer is "alive" by simply holding the ear against the tank; if a slight hum is heard, the transformer is sure to be in operation.

The necessary subdivision of the transformer core replaces part of the steel in the volume of the core with insulation. This so-called iron factor, which depends upon the thickness of the iron and the lacquer, reduces the effective area of the core by about 10 per

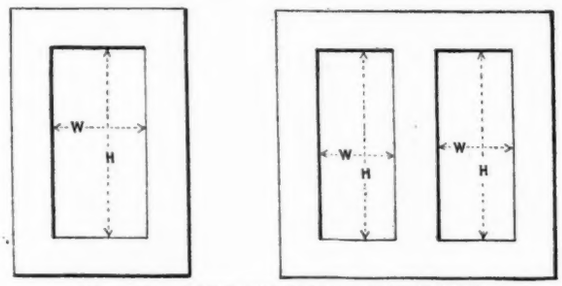


FIG. 10. CORE-WINDOW DIMENSIONS

cent. The factor is essential for the exact calculation of a transformer.

The losses in a transformer are composed of hysteresis losses, copper losses, and eddy-current losses. To keep these as low as possible is the only way to obtain the highest operating efficiency. While the copper and eddy-current losses depend chiefly upon the resistance and the arrangement of the windings and core, hysteresis losses are due to the necessary power required to produce and to maintain the alternating magnetic flux. It is assumed, hypothetically, that any piece of iron consists of countless magnetized iron molecules arranged in such an irregular way as to be, as a whole, without distinct magnetic polarity. When such a piece of iron is brought within a direct-current field, all its molecules will assume immediately a uniform position, having all North ends turned one way and all South ends the opposite way. Thus the whole piece of iron will show a distinct polarity. The straightening of the molecules is assumed to cause a certain amount of molecular friction, which takes a certain amount of electrical energy. It will be seen from this that if such a piece of iron is brought within an alternating-current field, all its molecules will have to undergo constant turning from one position to another one, 180 deg. apart. The speed of this magnetizing and remagnetizing depends on the frequency of the alternating current and amounts to 120 times per second for a 60-cycle circuit. This causes a considerable and constant molecular friction, which requires what is called the magnetizing current of a transformer, and represents the hysteresis loss. The amount of this loss is determined by four factors; the frequency, the volume of iron in the core, the density of the magnetic lines and the magnetic quality of the iron used. The first factor is decided by the current supply; the next two factors must be determined by calculation; the fourth factor requires research work of a magnetic-metallurgical nature. Such work has been done and has resulted in a number of alloy-steels which give very low losses per pound of steel.

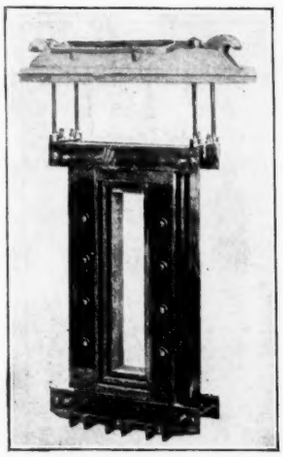


FIG. 11. TWO-LEGGED TYPE OF CORE

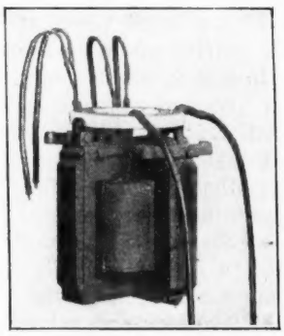


FIG. 12. STANDARD TYPE OF DISTRIBUTED CORE

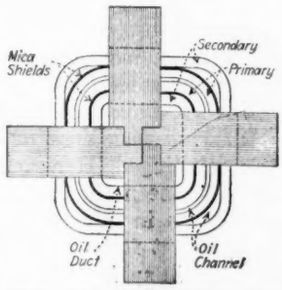


FIG. 13. END VIEW OF CORE AND WINDINGS

Every modern transformer has what is called a closed magnetic circuit. By this is meant that the magnetic flux, as produced by the coils, is carried on its entire path through magnetic material (iron) and that there are no air gaps to cross. It is therefore necessary to provide a top and bottom yoke to the core, which is laminated just like the main leg or legs of the core. These yokes should have at least the same total iron cross-section as the main legs in order to give the flux a uni-

form resistance along its entire path. For manufacturing reasons it is not feasible to wind the transformer coils by hand around the core legs. This means that at least the top yoke must be removable from the main legs. It is then possible to wind the coils on machines, to slide them finished over the legs, and to close the magnetic path by replacing the top yoke. It will be apparent that this makes necessary two or more joints in the complete transformer core. To make the magnetic resistance of these joints as small as possible is imperative for the most efficient operation of the transformer. Whatever method of joining is used, the metal path must be discontinued in every individual steel sheet, and it is therefore obvious that even the best method will give a magnetic joint resistance greater than that of a one-piece yoke.

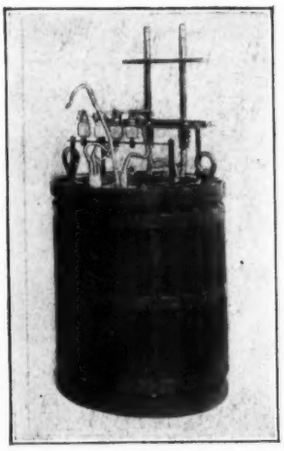


FIG. 14. CORE WITH 24 EXTERNAL LEGS

Two radically different methods are being employed today in making the joint in transformer cores—the interleaved joint and the butt joint. In the former method every other lamination of the leg and yoke is made the width of the legs shorter, so that all the longer pieces of the yoke take the place of all the shorter pieces in the core, and vice versa, as indicated in Fig. 2, which shows the thickness of the laminations greatly exaggerated. This gives a very simple and satisfactory joint. Its only disadvantage is the time it takes to open or to close sheet by sheet. The second method, the butt joint, used extensively in Europe, necessitates a very careful and most accurate finishing of the ends of the core and corresponding places of the yokes to insure a perfect magnetic contact. This finishing process, together with the heavy clamps necessary to hold the legs and yokes firmly together, makes this joint construction rather expensive.

Punchings for small transformers are made L, U or E shaped as in Figs. 3, 4 and 5 respectively. This means one leg and a part of the lower yoke, or two legs and the lower yoke, or three legs and the lower yoke are punched out of one sheet of steel in the same operation. For larger transformers the leg and yoke laminæ are punched or sheared separately.

The great majority of modern transformers use a winding of some circular nature, such as circular disk coils or cylindrical coils. It would therefore be ideal to use also an iron core of circular cross-section within these windings. However, from the foregoing it will be readily seen that as the cores must be built up of sheets it is impossible to arrive at the circular form. The simplest form of a core cross-section approaching the circle is an inscribed square, Fig. 6. Much iron is lost in the four segments, the area of the iron to the area of the circle is in proportion of 100:158. This factor, 63 per cent., is called the iron-space factor. For very small transformers such square cores are being used occasionally. Much better results are obtained with so-called "cruciform" core, Fig. 7, giving an iron space factor of 77 per cent. It is logical to increase the number of steps in the width of core-leg laminæ, in order to better the iron-space factor. Double cruciform-shaped cores, Fig. 8, five-step cores, Fig. 9, and cores with even a greater number of steps are being used. But it is evident that manufacturing complications soon enter where too many different widths of punchings for one size of core are used.

To accommodate different types of windings every size of transformer core has to have two flexible dimensions, W and H, Fig. 10, which are called the windows.

The simplest and probably most widely used transformer core is the two-legged type, Fig. 11. It is applicable and economical for all single-phase transformers from the smallest to the largest output. On small transformers and compensators both primary and secondary windings are sometimes arranged on one of the two legs only, the other being the magnetic return. The same type but with three identical legs is used for all kinds of three-phase machines. Both types may be used with the legs standing upright or lying horizontally one above the other. Interleaved or butt joints may be used.

A type of core used in America almost universally for all small and medium-sized single-phase distributing

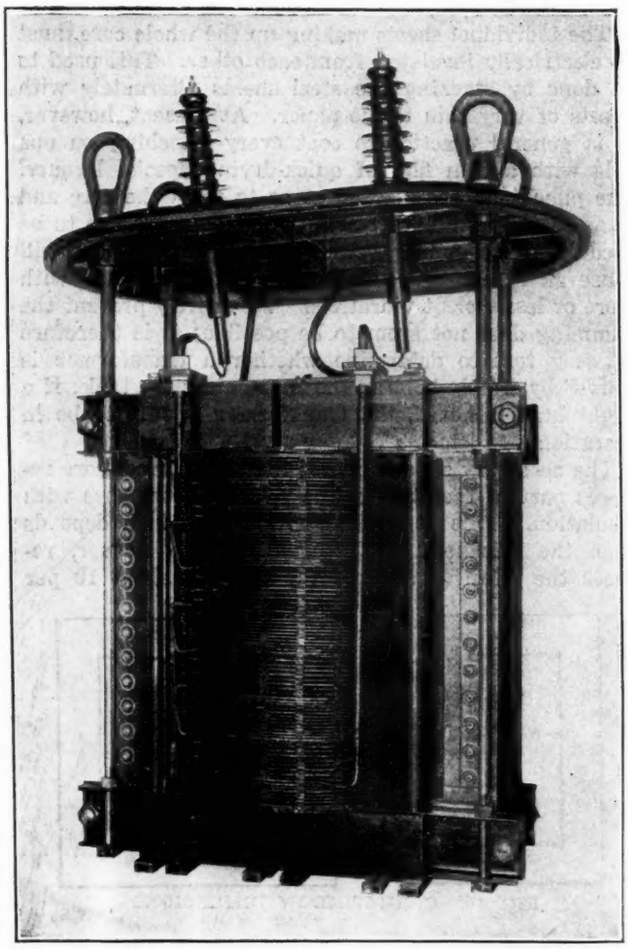


FIG. 15. SINGLE-PHASE TRANSFORMER HAVING A THREE-LEGGED CORE

transformers is the so-called distributed core or distributed shell design, Fig. 12. In this type the primary and secondary windings are arranged around a central, mostly polystep core, as in Fig. 13, and the mag-

netic return is made through three of four external legs. The cross-section of the external legs is equal to or somewhat greater than that of the central leg. This design lends itself readily to a very economical and rigid construction. An English concern went farther along this idea and manufactures a transformer that embodies the same principle of the distributed core, but uses as many as 24 external legs, Fig. 14. This makes the outside of such a transformer almost completely "iron-clad."

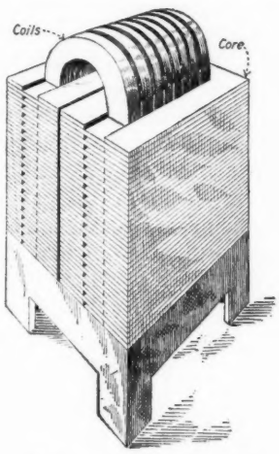


FIG. 16. SHELL-TYPE CORE

Instead of increasing the number of magnetic return paths, it is possible to design a very efficient single-phase transformer by using a core similar to the three-legged core, Fig. 10, but with the two outer legs having smaller cross-section than the center leg, and by placing both primary and secondary windings on the center leg only, as in Fig. 15. In this case the center leg only is designed with a possible maximum iron-space factor, whereas the two outer legs, carrying no windings and, serving only as magnetic returns, are usually left plain rectangular. This type of core, sometimes called "three-legged," may be used advantageously up to the largest single-phase units.

Another type of transformer core, known as the shell type, is shown in Fig. 16. The core of a shell-type transformer is similar to a three-legged core-type core, but usually contains so many laminæ as to make its cross-section long rectangularly. Consequently, shell-type transformers require long rectangular coils. In this type the core is built up around the coils, as shown in the figure. It can be said by several manufacturers the shell-type is at present being largely superseded by the core-type design. Only for transformers with an output of less than 2 kv.-a. or for air-blast designs does the iron-inclosed shell-type at present maintain its supremacy over the core type.

Safety Device for Hydraulically Operated Relief Valve

When the relief pipe of a turbine or engine installation exhausting into a surface condenser is fitted with a hydraulically operated atmospheric relief valve, there is a possibility of the operator leaving the water pressure on the piston of the hydraulic cylinder after closing the valve, when it should be shut off, thus permitting excessive pressure to build up in the condenser in case the vacuum is lost and the units attempt to operate noncondensing.

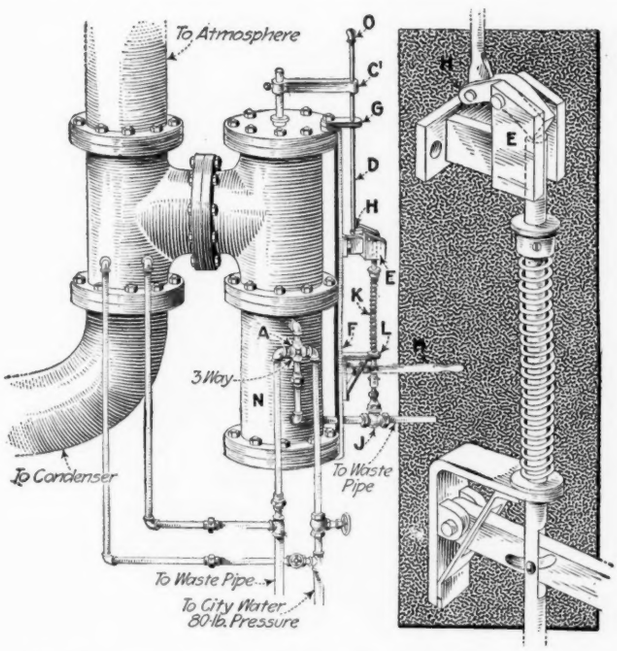
A simple but effective device has been designed in one instance to prevent such an occurrence: The 8-in. water piston that actuates the relief valve is controlled by a three-way valve *A* and is connected to the water-supply pipe and to a waste pipe, as shown. In case the operator admits city water (which is at 80 lb. pressure in this instance) in order to close the atmospheric valve, and for any reason should neglect to shut off the water pressure, a water-relief valve will automatically operate and relieve the pressure from the operating piston and thus permit the main relief valve to open before pressure is built up in the condenser.

The way this is done is as follows: The top cylinder head is drilled for the extension of the piston rod, and to this is attached an arm bent at right angles and having a hole at the outer flattened end *C*, which slides on a $\frac{3}{8}$-in. rod *D*. At the top of the rod *D* is a stop *O* and the other end of the rod is flattened and drilled with several adjusting holes so that the proper adjustment may readily be obtained for opening the water-relief valve *J*.

A bracket *E* is secured to a base that is bolted to a $\frac{3}{8}$-in. thick supporting iron *F*, which in turn is secured to the hydraulic cylinder as shown, the upper bolt also serving to hold the guide *G*. The bracket *E* is slotted at the top, in which is fitted a trigger *H*, one end of which is pinned to hold the rod *D* and the other end rests on the extension end of the valve stem of the water-relief valve *J*. The valve-stem extension is fitted with collars between which is a spring *K* that is under tension when the trigger *H* is in place. The bottom end of the extension rod is guided by an angle iron *L*, and just below the angle iron is a washer to prevent the spring *K* from having too great a movement.

One end of the lever *M* is pivoted to the bracket that is fastened to the cylinder *N*, and is attached to the valve stem by a pin that works in the slightly curved slot in the lever, which provides free movement as the valve stem moves up and down.

The operation of the device is as follows: In case the operator is suddenly called away after having opened



DETAILS AND APPLICATION OF THE RELIEF VALVE

the three-way valve, the water pressure of 80 lb. will force the piston in the water cylinder *N* up until the arm *C* engages with the knob *O*. Any further upward movement of the arm *C* disengages the latch *H* and allows the spring *K* to open the relief valve *J*, thus allowing the water pressure in the cylinder *N* to escape. This permits the relief valve to open without building up excessive pressure in the condenser.

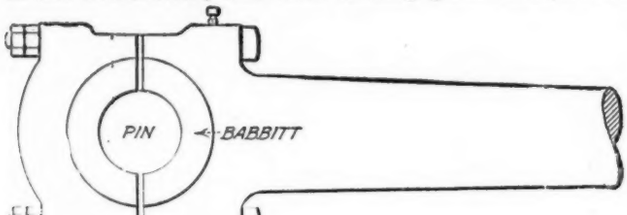
Pounding and Heating in a Diesel Engine

By D. L. FAGNAN

AFTER having been installed only three months, a 140-hp. horizontal oil engine suddenly developed a serious case of pounding. The explosions were so violent that the safety valve opened at every power impulse. The engineer could find no cause for such an unusual occurrence, and although he kept things going, he called for help. A local machinist, known to everyone as a handy man at anything and who understood and had operated this type of engine, was called in. While examining the engine he opened the splash door to feel the temperature of the crankpin and got a lump of hot babbitt metal on the back of his hand. Before the engine could be shut down in response to his alarm, the babbitt had completely melted out of the crankpin bearing and the rough shells had damaged the pin.

The construction of the shells and rod end was about as shown in Fig. 1. The machinist made all preparations for rebabbitting and heated the shells in a charcoal stove made from red brick placed in rectangular form three or four deep. He used an 8-in. nipple for a mandrel as it allowed about $\frac{1}{16}$ in. for machining. After inserting the proper number of shims, he clamped the halves together with a couple of bars of $\frac{1}{2}$ x $2\frac{1}{2}$-in. iron and four $\frac{5}{8}$-in. bolts and turned the shells in a lathe. He then put the crankpin in good shape by filing and calipering, finally polishing the pin by using a canvas band about 4 in. wide and plenty of emery and oil. He next smeared Prussian blue on the pin and by rocking the half shells back and forth was able to scrape and fit them to a fine bearing on the pin.

He gave the usual clearance of 0.006 in., as shown in the illustration, and after cutting good oilways and



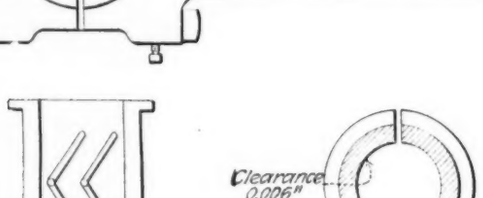


FIG. 1. CONSTRUCTION OF END OF ROD

smoothing their edges, assembled the bearings. Here is where he made an unfortunate mistake, as many other mechanics have done. Usually, the shells when leaving the shop are given a nice easy fit into the rod end, and as these shells seemed to be a very tight fit, he drove them home with a hardwood block and a light sledge. He gave the bearing a little play and allowed about 0.008 in. as side play, which is commendable.

On barring the engine over and finding that it turned easily, he started up, giving the pin considerable oil and a little graphite, but watching closely for heating. It came in a hurry. The pounding of the engine combined with the heating of the pin was serious. The bearing was saved by shutting down the engine quickly, but on examination the oilways were found piled full of babbitt. The bearing was scraped again, and after new oilways were cut it was assembled and the engine started. The same result followed, except that the bearing was so damaged that it was decided to rebabbitt. This was done and the engine was assembled, but left idle while the builders were notified to send a man to tame the critter.

The prize fell to my lot and I hurried to the plant, not knowing anything about the trouble they had been having. They declared that a sledge should have been used on it instead of good scraping tools and swore that the engine ought to be carted off to the scrap heap. When they got back to normal condition, they told me the whole story, adding that if the mechanic could not fix it in spite of his experience of 30 years on everything that would run, my chances were small.

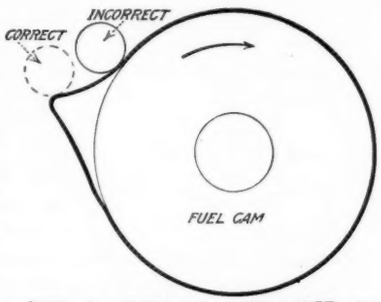


FIG. 2. ROLLER ACTUATED BY APPROACH TO CAM NOSE

Remembering what they had said about pounding, and the engine being assembled ready to run, the oil injection was checked up, revealing the fact that the engine was getting the oil 32 deg. too early. That explained the pounding as well as the fact that the safety valve spit fire at every power impulse. They had caused such an early injection of oil simply by screwing up the adjusting nut on the fuel needle until they had left no end play and the fuel needle was lifted by the approach to the fuel nose instead of the nose of the cam itself, as shown in Fig. 2. The shock must have been terrific, but unless the engine operated for some hours under such conditions, the heating of the pin would not be serious.

Some engineers would question whether an engine could be started under such conditions, but this type of engine starts easily by cutting out part of the compression, and only mild explosions take place until the release cam is put out of action and full compression occurs. The oil injection was reset at 5 deg. early by the use of a protractor. After loosening the nut on the fuel needle and having a man pump a heavy pressure until no more movement of the pump lever was possible, the nut on the fuel needle was gradually turned until a slight opening of the needle occurred, when the pump lever could easily be moved. This denoted the injection point, and by barring the engine backward slightly and then forward and bearing down on the lever of the fuel pump, the injection timing was easily checked up. The nuts were then permanently tightened and not disturbed again.

We had not yet found out why the pin heated. The pin and bearing being very large, the bearing pressure would not be high even with the pounding, and it was

necessary to look further for the cause. The crankpin bearing was taken down again and I showed them the excellent bearing they obtained by rocking the half shells on the pin and using prussian blue. Leaving the blue on the bearing, it was assembled again without the shims and was tightened up fairly tight, after which the engine was turned over with air a few times. Then the bearing was dismantled and when they saw the shells they understood the reason for the heating.

The first thing they had done was to distort the shells when they melted out the old babbitt. These shells are a true circle, cut in two, a small amount being taken off each half to provide for shims, using a saw for the separating process. More distortion occurred when they poured the babbitt. They should first have fitted the shells to the rod end by filing and scraping to a nice sliding fit and then paying attention to fitting the shells to the crankpin. In that case they would not have had to force the distorted shells into the rod end by hammering, thus entirely spoiling the good job they had done by scraping and fitting. The effect of this distortion was to force the ends of the shells inward and cause them to grip the pin at the point where they met. We proceeded to fit the half shells to the rod end and then to the crankpin, and when the engine was started again the heating troubles were at an end, as only a slight temperature was observed.

Test Shows Over 82 Per Cent. Efficiency of Motor-Driven Centrifugal Pump

In a paper read before the Minnesota Section of the American Water Works Association, F. W. Capellen, city engineer of Minneapolis, stated that in May, 1911, the city entered into a ten-year contract with the Minneapolis General Electric Co., now the Northern States Power Co., by which that company agreed to furnish current at 2200 volts to operate two or more 20,000,000-gal. pumps against a dynamo head of 240 ft., based upon a pumping set of 72 per cent. over-all efficiency, at a price of $4 per million gallons pumped, the understanding being that no current would be used between 4:15 p.m. and 6:30 p.m. on week days during the months of November, December, January and February. In November, 1916, a similar ten-year contract was made with the same company for the operation of a 30,000,000-gal. pump against the same head, and with the same efficiency, to be charged for at the same rate, with the provision that at a different dynamic head or efficiency the price should be adjusted accordingly. It was also specified that the motor to be used by the city should be capable of starting the pump when primed and with the check or gate valve in the discharge closed, and of bringing the pump to full speed without drawing more than 150 per cent. of full-load current from the source of supply. In 1910 and 1911 two 20,000,000-gal. pumps were installed, and in 1918, a 30,000,000-gal. unit.

The latter consists of an 1800-hp. three-phase G.E. slip-ring induction motor directly connected to two De Laval 24-in. single-stage pumps mounted on the same baseplate and connected in series. The unit was specified to deliver 30,000,000-gal. per 24 hours against a total dynamic head of 250 ft. It was supplied by the Minneapolis Electric Equipment Co. and is installed at Pumping Station No. 4 in North East Minneapolis.

The official acceptance test was made on May 28 and 29, 1918. The discharge was measured by means of a venturi meter, the capacity being calculated from manometer readings, while the discharge head was measured by two sets of calibrated gages and the suction lift by means of a mercury column. The power supplied was measured by three sets of watt-hour meters, calibrated by means of a portable set of standard instruments read during the official test under the conditions of current, voltage and power factor obtaining. The portable set included two single-phase wattmeters, one polyphase wattmeter, one voltmeter, four ammeters, and portable current and potential transformers. All intruments were checked and calibrated in the presence of witnesses. The test lasted 28 hours. The results were as follows:

Total pumpage in 28 hours, gal	37,719,500
Rate per 24 hours, gal	32,331,000
Discharge head, average, ft	235.13
Suction lift, average, ft	16.43
Total dynamic head, average, ft	251.56
Kilowatt-hours used	36,307.2
Combined efficiency of motor and pump, per cent	82.1
Average line voltage	2,406
Power factor, per cent	90.0
Motor efficiency under test conditions, per cent	95.5
Slip of induction motor, per cent	1.1
Temperature rise, deg. C	33.5
Starting current, percentage of full load current	113.0

The contract of the city with the Minneapolis Electric Equipment Co. provided a bonus of $500 for each 1 per cent. of efficiency exceeding 76 per cent. when pumping 30,000,000 gal. per day against a total dynamic head of 250 ft. The maximum bonus was limited to $2400. A penalty of $500 was provided for each 1 per cent. by which the efficiency might fall below 76 per cent., and the pump was not to be accepted if the over-all efficiency fell below 72 per cent. Seventy-six per cent. efficiency was exceeded at all loads tested, and the average combined efficiency, including the regular starting and other conditions incidental to a varying load in regular service, should not be less than 82.1 per cent. by more than 1 per cent. The over-all efficiency of 82.1 per cent. divided by the motor efficiency of 95.5 per cent. gives 85.97 per cent. pump efficiency.

The following operating data were obtained during the first three months after the test:

Gallons pumped	2,797,490,000
Power cost, per million gal	$3.63
Labor and supplies, per million gal	$2.27
Total cost, per million gal	$5.95
Head, ft	253.06
Over-all efficiency, per cent	81.4

Similar records for the first nine months subsequent to the test are as follows:

Gallons pumped	6,526,350,000
Power cost, per million gal	$3.72
Labor and supplies, per million gal	$4.77
Total cost, per million gal	$8.49
Head, ft	255.80
Efficiency, per cent	82.48

Figures are also available from two triple-expansion Holly-A frame pumps installed in the same plant in 1903 and 1904, and tested in September, 1904. These pumps have a capacity of 15,000,000 gal. per day each, and on test developed a duty of 162,000,000 ft.lb. per 1000 lb. of steam, reduction being made for slip. During 1908 the two steam pumps raised practically all of the water for the city; namely, 6,518,000,000 gal. against 250 ft. head. The cost of fuel, using Illinois screenings at $2.07 per ton, was $3.01 per million gal., the cost of labor $3.33, and other pumping costs 35c. per million gallons, making a total of $6.75. The cost today, with coal at $4.93 per ton, would be approximately $12.74 per million gallons. The low prices which the city realizes on its power contracts with the electric company are of course explainable in that the contracts were made some time ago and for a long term.

The Electrical Study Course—Addition of Alternating Voltages

Compares the addition of alternating voltage with the addition of direct voltages, and shows how to obtain the value of two or more alternating voltages in series.

WHEN determining the value of the voltage across a number of direct-current sources in series, it is merely necessary to add the values of the various sources in order to get the total voltage. Thus, in Fig. 1, three generators, *A*, *B* and *C*, are connected in series in such a way that all the voltages are added, making the voltage across *ab* equal to 110 + 125 + 240 = 475 volts. Hence, it is seen that in the case of direct voltages it is merely necessary to know the values in order to figure their sum.

When adding alternating voltages, however, it is necessary to take into consideration not only their values, but also what is called their phase relations. To make this clear, let us suppose that we have two alternating-current generators *A* and *B*, connected in series as shown in Fig. 2, and that their armatures are coupled together. Furthermore, assume that when the taps *ab* of *A* are at the center of the polepieces as shown, those of *B* are midway between the polepieces as shown in the figure. At the instant represented the voltage of *A* would be zero and that of *B* maximum. After a quarter turn of the armatures, as in Fig. 3, the voltage of *A* would be maximum and that of *B* zero. Assume that the maximum voltages of *A* and *B* are 100 volts and 200 volts respectively. The curves that correspond to the voltages generated during the revolution are shown in Fig. 5. It will be noticed that the maximum value of one is always 90 deg. away from the maximum value of the other, a fact indicated by the right angle separating the vectors, E and E_B, at the left in the figure.

This angular difference is called the phase difference of the voltages. For example, we would say that there is a phase difference of 90 deg. between the voltage of *A* and that of *B*. This phase difference between two generators depends entirely upon the relative positions of the taps *a* and *b* in reference to the polepieces. Thus, if the coupling between *A* and *B* of Fig. 2 were to be opened and armature *A* be given a quarter turn and the coupling reconnected, both sets of taps would occupy the same relative position as in Fig. 4 and the voltages would have no phase difference; they would then be said to be "in phase." Shifting the armature of either generator through some other angle would give us some other phase difference.

Returning now to the problem under investigation—

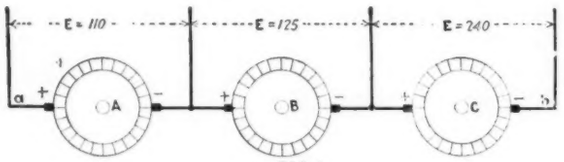


FIG. 1

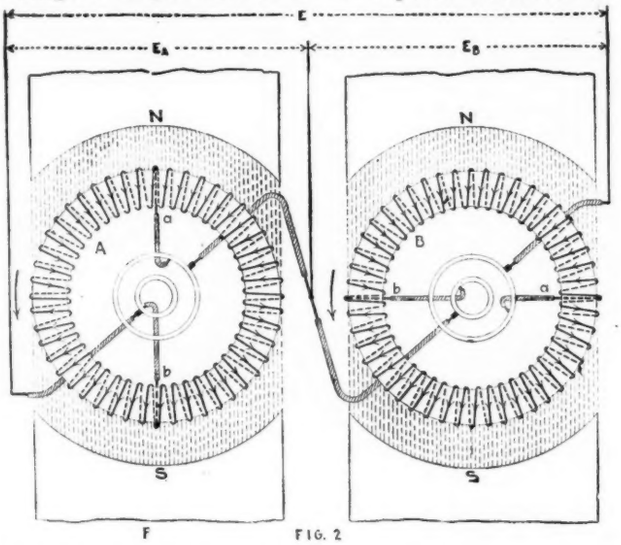


FIG. 2

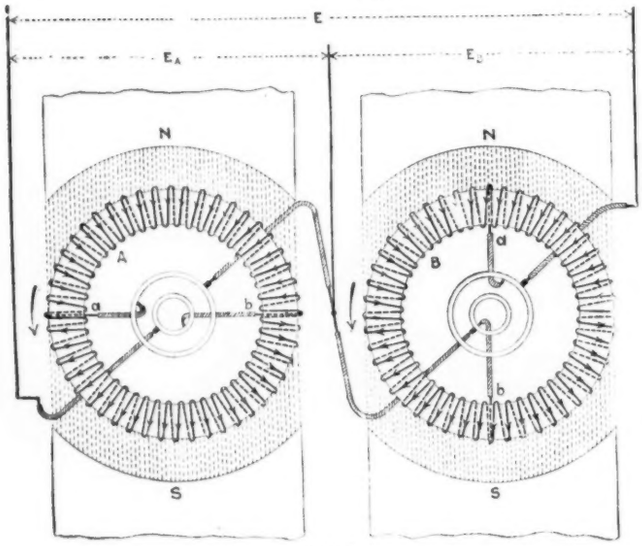


FIG. 3

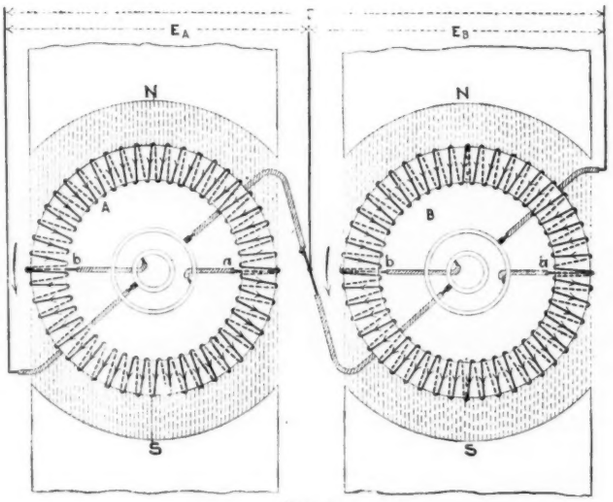


FIG. 4

FIGS. 1 TO 4. DIRECT-CURRENT AND ALTERNATING-CURRENT GENERATORS CONNECTED IN SERIES

namely, the addition of alternating voltages—let us see what the result would be in the case of the two voltages, E_A and E_B, that we have under consideration. Referring to the curves of Fig. 5, it is evident that at 0 deg. $E_A = 100$ volts and $E_B = 0$ volts, and that their sum is therefore $100 + 0 = 100$ volts. If we let E_0 represent the combined voltage at zero deg., we have $E_0 = 100$ volts. At 90 deg. we would have $E_A = 0$ and $E_B = 200$ volts, so that $E_{90} = 0 + 200 = 200$ volts. Likewise, E_{180} will be found to be 100 volts below the xy line, and so on. In fact, to obtain the voltage at any part of the cycle, all we have to do is to add the distances of the curves from the xy line.

In Fig. 6 the curves of Fig. 5 have been repeated, and additions of their heights are shown for every 30 deg. Thus the point b_3 is obtained by adding the height bb_1 to the height bb_2, c_3 by adding cc_1 to cc_2, etc. At the 120-deg. position ee_1 is below the xy line and ee_2 above it. It is therefore necessary to deduct the length ee_1 from ee_2, leaving the height ee_3. The same procedure must be followed in all other cases in which the distances are on opposite sides of the xy line.

It will be noticed that the curve E that is drawn through the resultant points is a sine curve like the two of which it is the addition. However, the maximum value of curve E is only slightly greater than the

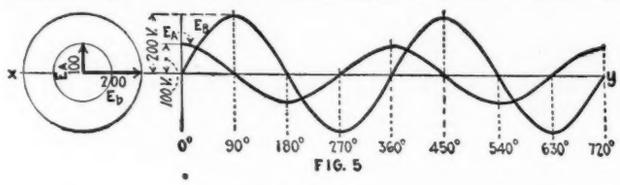


FIG. 5

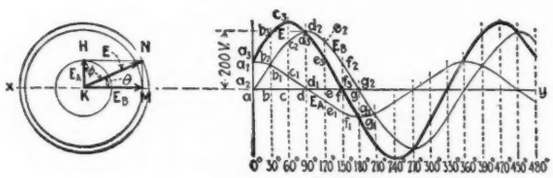


FIG. 6

FIGS. 5 AND 6. ADDITION OF TWO ALTERNATING VOLTAGES 90 DEGREES OUT OF PHASE

maximum of E_B and nowhere near the value we would have obtained if we had added the maximum values of E_A and E_B, which would have given us $100 + 200 = 300$ volts. Since E is a sine curve, its maximum height could be represented by a vector, which would in that case represent the vectorial sum of E_A and E_B, as shown to the left, Fig. 6. Since the maximum values of this resultant occur at angles different from those at which either E_A or E_B has its maximum value, it follows that the resultant is out of phase with both of the added or component voltages.

It has been found that there is a very easy method of determining both the value and the angle of the resultant voltage. This consists of constructing a parallelogram, such as $HKNM$, shown on the left in Fig. 6, the lengths of whose sides are equal to E_A and E_B, and then drawing the diagonal from K to N. The length of this diagonal is equal to the maximum of the resultant voltage, and θ and ϕ are the angles by which it differs in phase from E_B and E_A respectively. It is thus seen that it is unnecessary to undertake a cumbersome construction such as that of Fig. 6 in order to determine the sum of two alternating voltages, since the resultant curve E can just as well be constructed from the vector E of Fig. 6 after this vector has been constructed in the manner just described. It will be noticed that in Fig. 6, KMN is a right triangle of which the side KM is equal to E_B and the side MN to E_A. Consequently, we have that $(E)^2 = (E_A)^2 + (E_B)^2 = (100)^2 + (200)^2 = 50{,}000$, from which $E = \sqrt{50{,}000} = 223.6$ volts, showing that the sum of the voltages can be obtained mathematically without resorting to any construction at all, when E_A and E_B are at right angles to each other.

When the two voltages are in phase, their sum is found by simple addition. This case is illustrated in

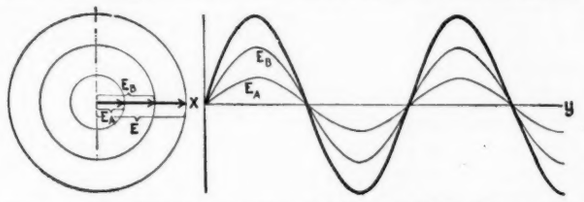


FIG. 7. ADDITION OF TWO ALTERNATING VOLTAGES IN PHASE

the curves, Fig. 7. The resultant vector E is equal to $E_A + E_B$ and is therefore 300 volts. Adding the two curves E_A and E_B will give the resultant curve E.

Problem 1 in last lesson was to find the voltage at instants 25 and 65 deg. in an alternating-voltage cycle, Fig. 8, the maximum value of which is 250 volts. In the previous lesson it was shown that the voltage at any instant in a sine curve of alternating electromotive force is equal to the maximum value times the sine of the angle at which the voltage is calculated. In this problem it is desired to determine the voltage at 25 and 65 degrees. Sin 25 deg. and sin 65 deg. are 0.4226 and 0.9063 respectively, as found from a table. Therefore, if we let the maximum volts be represented by E and the instantaneous volts by e, we have at 25 deg. of the cycle, $e = E \sin 25$ deg. $= 250 \times 0.4226 = 105.6$ volts, and at 65 deg. $e = E \sin 65$ deg. $= 250 \times 0.9063 = 226.6$ volts.

In problem 2 it was requested to find the cycles per second and the alternations per minute of a 16-pole alternator running 187.5 revolutions per minute. In the last lesson it was shown that the frequency, $f = \frac{PS}{120} = \frac{16 \times 18.7}{120} = 25$ cycles per second. There are two alternations per cycle and 60 seconds per minute,

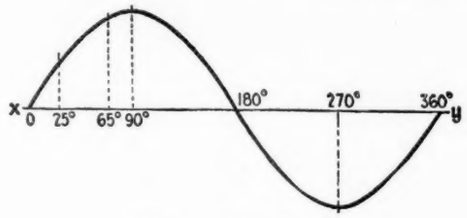


FIG. 8. SINE CURVE

therefore in this problem, alternations per min. $= 25 \times 2 \times 60 = 3000$.

1. Two alternating voltages, one of 300 volts and the other of 400 volts, have a phase angle of 90 deg. What would be the resultant voltage if they were to be connected in series?

2. At what speed must a 12-pole alternator run to generate a 50-cycle voltage?

Jim and Fergus Go Visiting

BY JAMES F. HOBART

"HEY, JIM! Let's visit the Big Four shops at Beech Grove, about ten miles from Indianapolis. There's a lot of stuff down there that is worth seeing." And so we went to Beech Grove, and we were mighty glad we did. Two of the turbines were running, furnishing current to operate the big shop; but the third one had just been dismantled and part of it sent to their own shop for repairs.

I didn't want Fergus to get "in bad" with the chief, so I wished him upon the assistant engineer, who took him into the boiler house and let him go snowblind from looking into the combustion chambers of some of those big boilers where the fire was white hot.

While we were returning to town, Fergus asked me what the assistant meant by his remark regarding stokers when he said, "stokers are just like women—the most interesting things in the world, but a fellow never understands them." "Now just what did he mean?"

I put two and two together, pieced Fergus' remarks with what the chief had said and concluded that they were having the time of their lives with their stokers and with various kinds of coal. The chief had stated that he always asked for West Virginia coal, but during the war period he was mighty glad to get any coal at all, of any kind.

FIG. 1. "WE DO OUR OWN REPAIRS," SAID THE CHIEF

The chief had also said that when he had to burn West Virginia coal one type of stoker was right in its glory and he never wanted anything better, but that the coal did not burn so well with the other type of grate. When he had to burn Indiana or Illinois coal, then things were different, and the stoker action was just reversed, the one giving satisfaction with West Virginia coal freezing up.

While inspecting the plant I asked the chief what power factor he ran under and he replied about 72 right then, but that it was not very good, although it used to be a whole lot worse before the Government took over the railroad and the shops. Said he: "Then, when piecework was the rule, the men would start some

FIG. 2. GOT DOWN TO BUSINESS AT ONCE

of the big machines that are scattered throughout the shop, use a machine for a few minutes perhaps, and then allow it to run idle all day. Such work as that just raises 'hob' with the power factor. It overloads the generators and underloads the turbines, and there you have it. Since the Government has taken over the shops and abolished piecework, things are better. They are after some efficiency from the big machines and will not let them run except when in use, and that and other changes have raised the power factor from 40 or 50 to 72. That is not bad, considering that the steam plant is operated noncondensing and that the peak load on the two generators sometimes runs up to 1250 or 1300 kilowatts."

"But why is the plant run noncondensing?" I asked.

"Because," replied the chief engineer. "the water supply has fizzled out. When the plant was first put in, there was plenty of water and we used to pull a vacuum of over 29 in., not by a spring gage, but on a correct mercury column. We used so much water that we didn't raise its temperature more than three degrees in passing it through the condenser. But things have changed. We used to pump it but twenty feet; now, we have to pump it two hundred feet. So we just cut out the whole business and are running noncondensing. You know what that means with turbines. It cuts off the real economy and leaves only the cost and the expense.

"Yes, sir! That is all there is to the turbine business. The high-pressure end is cost and trouble, and the low-pressure portion is economy and comfort. All

the profit of running a turbine comes from the low-pressure end, and that being cut off, as in our case, leaves us in a pretty bad fix. I have been trying to induce the powers that be to put in a spray pond so we could cool the water and use it over and over again, but I don't know when I will get it.

"To prove that it would be profitable to them, I gave them facts and figures which they accepted right off the reel and said it was a good thing and that I ought to have it. But that makes it all the worse, for I find that the things to which they agree the quickest are the slowest in coming. I had rather that they had opposed the scheme a bit and that I had argued the matter with them, for then they are much more likely to come across when convinced. But now the thing is likely to drag along without my ever hearing from it again.

"Yes," continued the chief, "I have proposed an idea for getting all the direct current they want for nothing, save the first cost of the machinery, plus nothing for

1
IT MAY BE AN IMPROVEMENT BUT IT COSTS MONEY. GOOD DAY
2
A CONVENIENCE! PERHAPS, BUT THERE'S THE ELEMENT OF COST. NOTHING DOING
3
YOU CERTAINLY PUT IT WELL. HOWEVER, THE FINANCIAL CONSIDERATION REMAINS.
4
WHAT'S THAT? THE FINANCIAL CONSIDERATION SHOULD INDUCE US TO INSTALL IT? JUST WHAT DO YOU MEAN?
5
EH! YOU SAY IT WILL SAVE US MONEY. NOW THAT SOUNDS SENSIBLE!
6
YES, YES, GO ON. YOU INTEREST ME STRANGELY!

FIG. 3. WHEN THE CHIEF ARGUED FOR IMPROVEMENTS

operation. We use a good deal of direct current in the shop, and those two motor-generators are running all the time. I have shown them that by putting in a mixed-pressure turbine and using the exhaust from the steam hammers in the shop and the exhaust from some other steam-using shop tools, they could run a 220-volt d.-c. generator with the occasional use of a very small quantity of live steam, thus doing the work with the exhaust steam and the regulation with the high-pressure steam.

"This would cost nothing but the installation of the machinery. It would do away with the use of the two motor transformers, which are a large part of our load, and I could do all the rest of the work with one turbine instead of the two now in use all the time. But," he added, "maybe I'll get that and the spray pond as well as soon as we get the cross-compound engine that has been authorized for several years, and which has not arrived."

"How does it happen that the exciter unit is set right in the center of the station, between the motor generators and the three turbine generators, which are on the other side of the exciter?" I asked.

"It was placed there by the designer of the plant" replied the chief, "and I am very glad that it was, because we use that exciter a lot when the rest of the plant is not running, nights and Sundays, and for charging storage batteries on cars after having been repaired or overhauled in the shop. We build up just the voltage required and let the exciter run direct to the batteries at that voltage.

"Some amusing things have happened in connection with battery charging. One morning one of the runners was fussing around the exciter when I came in. He said he could get no voltage indication on the exciter voltmeter no matter what he did.

"I told him that he had got its polarity reversed, but he could not be made to see how that could have happened. The machine was exciting the alternators all right, but nobody knew what voltage it was giving as the machine could not indicate upon the voltmeter when reversed. At the first opportunity we reversed the polarity of the fields and the voltmeter at once went back to business.

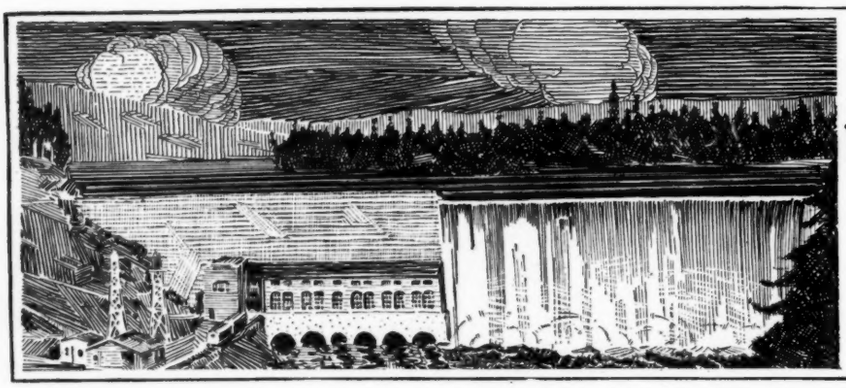
"I was curious to know how the fields became reversed and so pressed the man for an exact account of just what he had done when starting the exciter. It developed that he switched on the batteries that were to be charged and then stepped around and started the exciter. 'Threw on the batteries before you started the exciter, did you?' I asked. 'Didn't you know that would reverse the fields?'

"'How could it do that?' he asked. 'It was not one second after the batteries were on before I started the exciter. How could the fields reverse in that short time?'

"Well, to this day I have not been able to make that man see that the exciter fields did not require time instead of instantaneous action to be reversed.

"Another time," said the chief, "the exciter was reversed, probably in the same manner. It was on Sunday and nothing was running in the power house, and it became something of a question as to how I was to reverse the exciter fields again. Finally, I went to the storage-battery house and found they had one battery there that was about half charged. It was connected to the charging line from the power house, and after putting paper under the exciter brushes it was started up and I finally got it reversed by the current from the storage battery."

The question as to where disabled ex-service men are being reëducated is answered by the fact that 5077 disabled soldiers, sailors, and marines under the direction of the Federal Board for Vocational Education are in training in more than seven hundred different institutions throughout the country. No less than 546 schools and colleges now number wounded soldiers among their students; and 198 commercial and industrial establishments have disabled men on their forces learning trades. In order to give the men the kind of courses they want as near their homes as possible, the Federal Board for Vocational Education has selected all types of institutions for their training.



POP'S WATER-POWER COURSE

By

John S. Carpenter

"HEY, Jimmy, look me over, kid. Say, don't I look happy?" joyously exclaimed Pop as he strutted into the turbine room with a fat, black cigar at a rakish angle.

"Spill it, Pop, and tell me the glad tidings," responded Jimmy, mopping his brow.

"Well, jes' as I got through feedin' at the Greasy Spoon Beanery they was an extry come out announcin' the slidin' down the chute of old Kaiser Bill. The latest dope has it that he's goin' so fast that the royal pants has wore through and the splinters is goin' deep into his brains." Pop smiled from ear to ear and paced the floor with unalloyed satisfaction.

"I'm glad it's over, Pop. I was wishing—"

"Hey, Kelly," interrupted Pop, "tie down the big whistle and let her alone till I hollers." Turning again to Jimmy: "And what's more, the load bein' light, I'll git Casey to stay here so you and me kin go up the creek and see our new plant."

"Thanks, Pop; I was wishing for something like that. Then we can talk over all the fine points." So saying, Jimmy washed up and slipped into the uniform of civilization, and the two hopped into Pop's Ford. It was plain that Pop felt devilish, for he let the contraption out wide open and it was not long before they could see the dam of the new water-power plant. Pop tied the Lizzie at the log-boom anchorage and they got out.

"I can guess, Pop, that this is the log boom," said Jimmy, lighting one of Pop's fat, black cigars. "These logs are joined together by short pieces of chain spiked to the logs. I don't need to be told that they are intended to catch the driftwood and weeds coming down the river and so protect the turbines."

"Darn right, son. Now, when the place gets cluttered with drift, they send somebody out in a rowboat to clear it. The space behind the log boom and in front of them things up there that looks like prison doors—what they calls racks—is called the forebay."

"I s'pose that the racks are to catch any small trash that the log boom lets pass," volunteered Jimmy.

"Yep, but more partic'ler to catch leaves. Let's go down on top of that runway acrost the racks."

Jimmy seemed to be bothered about something which he presently voiced.

"How in thunder do they clean out the leaves, Pop?" As they got to the runway, they stopped to look at a ditch-like affair in the runway floor.

"See them rakes?" asked Pop, pointing to some stout-looking rakes with twelve-foot handles. "Well, they rakes the leaves up them racks and then dumps 'em into this ditch; then, you can see that the thing slopes considerable, so with these hose connections they gits water to flush the leaves out over into the spillway side."

Now they had a good look at the racks. They were made up in sections about 3 ft. wide and 10 ft. long. The bars of the racks were of 3-in. flat iron $\frac{1}{4}$ in. thick and spaced about $\frac{3}{4}$ in. clear between the bars. The sections were tied together with $\frac{3}{4}$-in. bolts through short pipe spacers.

Satisfied as regards the racks, the two went back a little, and Jimmy, always curious, blurted out: "Say, Pop, see the grooves in the side walls of the penstocks? What are they for?"

"Them, the lecturer told us, are the stop-log grooves. S'pose they want to drain the water out of this forebay, they throw them dressed timbers across the forebay with the ends in them grooves, so by and by they have a timber wall that will be tight enough to let a man go down and work in the forebay."

"Very fine," agreed Jimmy. Then, clearing his throat for a grandstand play, he began, "Now, Pop, how do they know what size to make the forebay and how wide to make the racks?"

"That's just what you didn't git at the last lecture," declared Pop as he relighted his cigar stump. "All that fine dope, all that high-brow chatter passed in one ear and out the other."

"Of course," pleaded Jimmy, trying to justify himself, "I can see that the passages must handle so much water at a certain velocity."

"Well, it's this way," Pop responded. "The velocity through the racks and penstocks is usually about $1\frac{1}{2}$ ft. per second on low-head plants. If, for instance, you have to handle 150 cu.ft. per second, dividin' by $1\frac{1}{2}$, we git 100 sq.ft. area. Now, that could be made 10 ft. wide and 10 ft. deep, or any other reasonable dimensions that would equal 100 square feet."

"If the velocity allowed through the racks is the same as that through the penstocks, why is it that the forebay was widened out just in front of the racks?" protested Jimmy as he pointed toward the racks.

"Son, do you need to be told that them rack bars—there's about a million of 'em I guess—take up some of the area in the passage?"

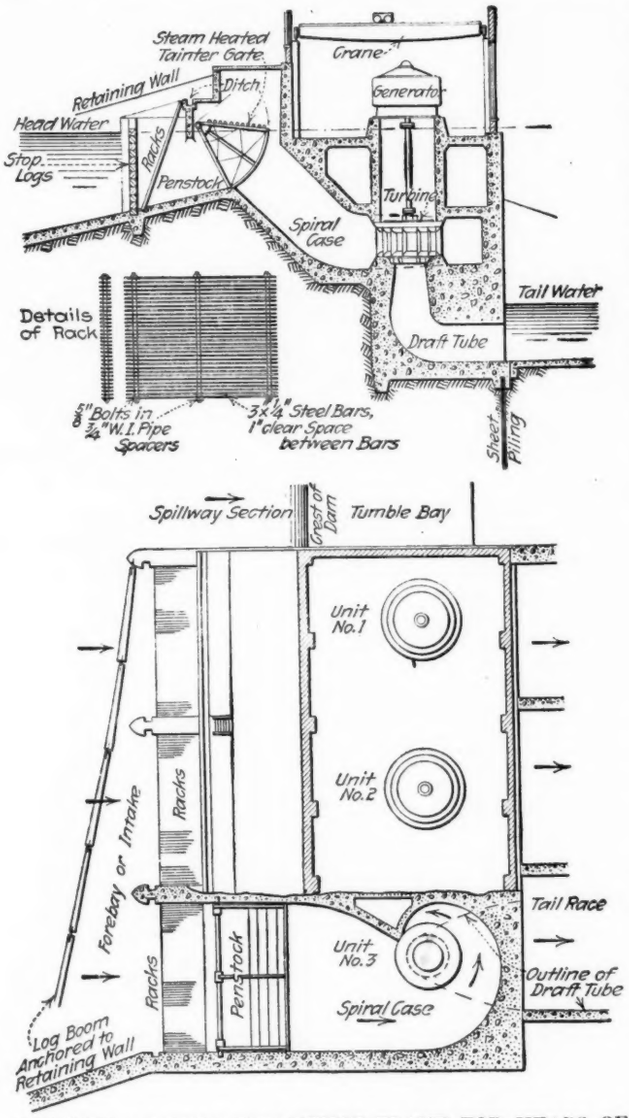
"I pass, Pop. I'll buy the cigars; you're right."

"How they get to know what velocity to allow is what got me all het up at the last lecture. You heard me ast him?" Jimmy nodded. "Well, what I got out of it is this. If they make the passages very large, the friction will be low and revenue will be saved because power will be saved; but agin this we must charge the extry first cost and the interest on the investment. On the

other hand, if the velocity is high, so's the friction, and some power is lost that might 'a been fed to the busbars; but the first cost of the penstocks and the interest is less. So the wise engineer will try to take account of all this and proportion his penstocks accordin'."

"I didn't get all that he said about spouting velocity," said Jimmy.

"The spoutin' velocity of water is jes' that velocity the water would have when flowin' out of a nozzle because of its pressure. If the water was under 16 ft. head, the spoutin' velocity would be about 32 ft. per



SECTIONS OF HIGH-EFFICIENCY PLANT FOR HEADS OF FROM 15 TO 50 FEET

second. If it's under 64 ft. head, it's 64 ft. per second. You jes' multiply the square root of the head by 8—or 8.02 if you want to be real fussy."

"Oh, now I see; it's just the same velocity that a falling body would have after falling so many feet."

"Yep, Jimmy, that's it. The velocity goes up with the head, until at very high heads it gits so it'll eat castin's if there's any grit in the water. Makes a fine sand blast."

Jimmy made a rapid but accurate mental calculation. "Say, Pop, on that high-head Swiss plant where they got 3000 ft. head I just figured that the spouting velocity was 440 ft. per second or just 5 miles per minute. Some speed to that water!"

"Now, son, remember how to figger the spoutin' velocity, because the lecturer told us that we'd have to use it when studyin' turbines; for all turbines are designed on so many per cent. spoutin' velocity here and so many there. I figgered out a table of spoutin' velocities for my own fun and here it is:

Head	1	10	20	30	40	50	60	70	80	90	100	200
Velocity	.8	25	36	44	50	57	62	67	72	76	80	114

You notice that the spoutin' velocity goes up pretty fast compared to the head at first, but after a while it slows down."

Through a stair well they went down to where they could see the Tainter gates, which seemed to Pop to give occasion for one of his eloquent explanations.

"They calls these things Tainter gates, and they is nothin' more than a thing to shut off the water with. Now, this one right here," explained Pop, bending low, "is het with steam, the idea bein' that when this one melts up the ice that is sure to form around it, they can start the water flowin' with it and then, as soon as the water is circulatin', it will tend to break up and melt such ice around the other gates. Now, in under that big cover are the heatin' coils that are connected to the donkey biler inside the generator house.

"Say, Jimmy," exclaimed Pop, looking earnestly at his Ingersoll, "it's time to go. The next time we'll crawl into the spiral case, down the draft tube and take a peep at the spillway."

While Jimmy extracted himself, Pop had the Lizzie cranked and they were off.

British Government Support of Foreign Trade

The development of British overseas trade is a question which is much before Parliament these days, says the American Chamber of Commerce in London, and the news in this line is of significant interest to American exporters.

The industrial group in the House of Commons is understood to have entered into the question and to be urging upon the Government the necessity for reorganizing the British diplomatic and consular services as a matter of national protection. This industrial group is urging particularly a department of overseas trade, which shall be much more highly organized and extensive in scope than the present department and that having been founded to assist business and business men, its head should be a man well trained and versed in business affairs and free from political or departmental handicaps or prejudices. The basic points of the policy which the industrial group recommends are:

1. The unification and specialization of the diplomatic and consular services for dealing with the defined trade and racial areas.

2. The best method of bringing into touch British business men who are specially acquainted with the trade and affairs of foreign countries with the officials of the Department of Overseas Trade dealing with those countries.

3. The best method of maintaining an interchange of opinion and information between all British chambers of commerce in foreign countries and official British representatives in those countries.

Alignment Chart for Finding the Properties of Saturated and Superheated Steam

By CLINTON E. PEARCE

The accompanying chart for finding the thermal and physical properties of steam simplifies the solution of various problems relating to the generation and use of steam. Its accuracy is comparable to that of the ordinary slide rule, and so it gives results sufficiently close for most engineering requirements.

AFTER water has been heated to the boiling point corresponding to the pressure exerted on it, further addition of heat does not increase the temperature. Instead, the water begins to vaporize and form steam, and the volume increases rapidly. If the water and the steam are considered together, this gradual formation of steam will give a mixture in which the amount of water is continually decreasing while the amount of steam is increasing. The mixture is called wet steam, because of the moisture in it. The percentage of steam in 1 lb. of it is called the quality, and is designated by the letter x; and the percentage of water, especially when small in amount, is called priming. Thus, water has a quality of 0; a mixture of 2 lb. of water and 3 lb. of steam has a quality of three-fifths, or 0.6; while steam primed 2½ per cent. has a quality of 97½ per cent., or 0.975.

The Heat of Vaporization

The amount of heat required to vaporize 1 lb. of water of a given temperature into dry steam at the same temperature is known as the heat of vaporization and is designated by the letter L. When the steam is wet and part of the full pound is still in the form of water, the heat that has been added is less than L and is directly proportional to the amount that has been vaporized, or, in other words, to the quality x. The general expression for the heat of vaporization will then be xL, in which x may vary from 0 to 1, and L will change somewhat with the pressure.

The amount of heat added to 1 lb. of dry steam to superheat it may be calculated from the product of the amount necessary to raise 1 lb. through 1 deg., and the number of degrees it has been raised, or superheated. Therefore, if a is the number of heat units required to raise the temperature 1 deg. and S is the number of degrees of superheat, the general expression for the heat added will be aS. The value a for any substance is known as the specific heat of that substance. For water a is equal to 1, but for superheated steam it varies with both the pressure and the temperature and must be read from complicated tables.

The total amount of heat necessary to raise 1 lb. of water from 32 deg. F. to the boiling point, and then to evaporate it either to a quality x or to a superheat S, is called the total heat and is designated by the letter H. The general expression for this value for wet steam is $h + xL$, and for superheated steam it is $h + L + aS$. Therefore, if water alone is considered, the quality is zero, and $H = h$; and if the steam is dry but not superheated, the quality is unity and $H = h + L$; h represents the heat of the liquid.

The volume of 1 lb. of water at 32 deg. F. and under 14.7 lb. pressure is 0.016 cu.ft., and the volume at 468 deg. F. and 600 lb. pressure is 0.02 cu.ft. This is so small in comparison with the volume of the dry or superheated steam made from the same water that it can be neglected in practically all problems; therefore, it will be assumed that the volume of water is zero in wet steam. Thus, in wet steam of a quality x the volume will be that of the steam alone and will be proportional to x. The volume of 1 lb. of dry steam is known as the specific volume and is designated by the letter v. The expression for the actual volume of wet steam will be xv. When superheated steam is considered, the actual volume must be found from complicated tables, as there is no simple relation between it, the amount of superheat, and the specific volume.

Total Entropy Made Up of Three Parts

Just as total heat is made up of three parts—heat of the liquid, heat of vaporization and heat of superheat—so total entropy, designated by the letter N, is also made up of three corresponding parts, called the entropy of the liquid, the entropy of vaporization and the entropy of superheat. The expressions for the first two values are n and $\frac{L}{T}$. Heat is added to water or to superheated steam while the temperature is changing, and the calculations required to find the value of the ratios during these operations are very complicated; so n must be taken from tables. During evaporation the temperature is constant, and consequently the value of the entropy is L divided by T, the letter T representing absolute temperature. The total entropy of wet steam can be calculated from the expression, $n + x\frac{L}{T}$, but its value for superheated steam must be found from charts or tables. There is no name for the numerical value of these expressions, so they are merely stated as so many units of entropy.

To avoid the use of cumbersome tables, which may require many pages to list all the necessary information, some authors have published complicated charts to show all the various properties of steam, including the effect of having it wet or superheated. Two of the five fundamental properties are usually selected as the horizontal and vertical scales or coördinates, and then a multitude of cross-curves have to be drawn in to represent the other three, together with different values of x and S. The general advantage of using such charts is that all required values can be read at once without any calculation. The accuracy depends upon the size of the chart, but is always less than that of the tables. The very complexity, however, of these charts makes finding the proper point of intersection

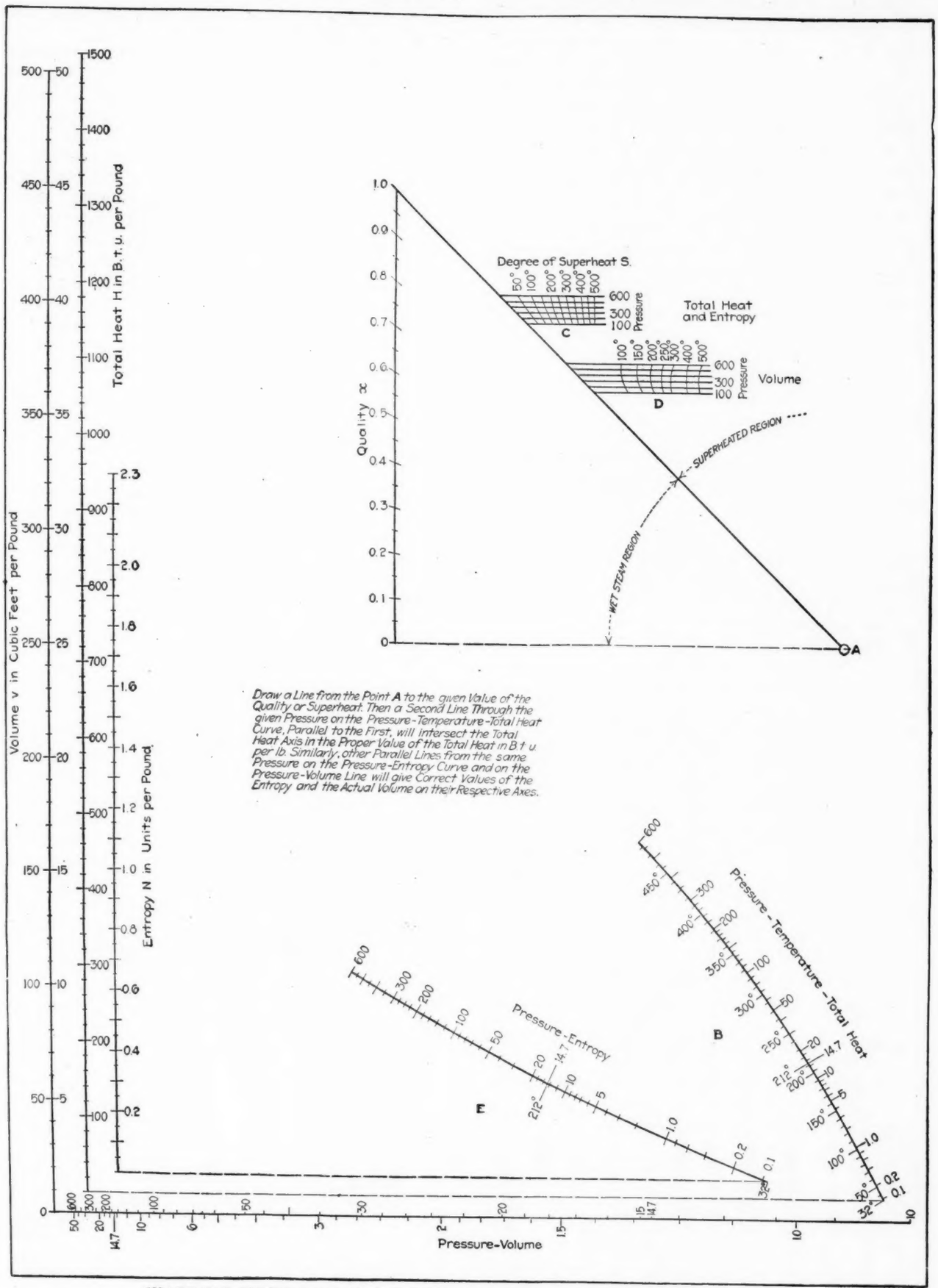

Volume v in Cubic Feet per Pound
Total Heat H in B.t.u. per Pound
Entropy N in Units per Pound
Quality x
Degree of Superheat S.
Total Heat and Entropy
Volume
Pressure
SUPERHEATED REGION
WET STEAM REGION
Draw a Line from the Point A to the given Value of the Quality or Superheat. Then a Second Line Through the given Pressure on the Pressure-Temperature-Total Heat Curve, Parallel to the First, will intersect the Total Heat Axis in the Proper Value of the Total Heat in B.t.u. per lb. Similarly, other Parallel Lines from the same Pressure on the Pressure-Entropy Curve and on the Pressure-Volume Line will give Correct Values of the Entropy and the Actual Volume on their Respective Axes.
Pressure-Temperature-Total Heat
Pressure-Entropy
Pressure-Volume

CHART FOR FINDING THE PROPERTIES OF SATURATED AND SUPERHEATED STEAM

of two of the many lines an operation that is greatly liable to error unless extreme care is used.

The accompanying chart shows a method of graphically representing the variations in the five fundamental properties of steam, with different values of x or of S, that is much more convenient than the usual coördinate type. It is so constructed that if a straight line called the slope line is drawn through the point A and a parallel line is drawn through the Pressure-Temperature-Total Heat curve B to the vertical Total Heat axis, the three intersections representing quality x (or superheat S), the pressure P (or the corresponding boiling point) and the total heat H will give the correct corresponding values of those properties; that is, the total heat at the given pressure and quality will be read directly. On the same chart two other lines parallel to the first (through A), one from the same pressure on the Pressure-Entropy curve E to the vertical Entropy axis and the other from the same pressure on the horizontal Pressure-Volume line to the vertical Volume axis, will also give directly the values for entropy and for volume. This general characteristic of having points corresponding with each other in a line or in parallel lines gives the name of "Alignment Chart" to this construction.

Basis of Construction of Chart

The construction of this chart is based on the following explanation, which is given in full for the Pressure-Temperature-Total Heat relation only: The curve B is plotted so that for any pressure the horizontal distance, or abscissa, from the Total Heat axis to the point on the curve is equal to the heat of vaporization L, while the vertical distance, or ordinate, of the point above the zero of the Total Heat axis is equal to the heat of the liquid h. Then each point on the vertical quality axis is drawn so that the tangent of the angle of the slope line through it and A is equal to the quality x. Now, if from any point on the Pressure-Temperature-Total Heat curve B a line is drawn parallel to a given slope line, it will intersect the Total Heat axis at a distance above the horizontal line through the pressure point on the curve B equal to the abscissa times the tangent of the angle. Thus, the value of the total heat H is equal to the ordinate representing h plus the product of the tangent of the angle x and the abscissa L; or, $H = h + xL$. The ordinates and abscissas for the Pressure-Entropy curve E are n and $\frac{L}{T}$ respectively, and for the Pressure-Volume line are zero and v. The ordinates of this latter line are zero because the volume of 1 lb. of water is assumed to be zero, in comparison with the volume of steam formed from it.

The range required for volume was so great—since v is 333 cu.ft. at 1 lb., absolute, 38.38 cu.ft. at 10 lb., 8.51 cu.ft. at 50 lb., and 0.76 cu.ft. at 600 lb.—that sufficient accuracy could not be obtained with a single vertical scale similar to the others. A double construction was therefore used, with the lower group of pressures from 1 lb. to 50 lb., and the upper group from 10 to 600 lb. The lower group on the horizontal Pressure-Volume line corresponds to the large graduations on the left-hand side of the Volume axis, and the upper group corresponds to the small graduations on the right-hand side. If it is remembered that the specific volume decreases as the pressure rises, this arrangement will cause no confusion.

As there is no simple way of representing the properties of superheated steam on the basis of an apparent quality greater than unity, or 100 per cent., the following construction was finally chosen: The diagram C for total heat in the Superheated Region was constructed by drawing horizontal lines for pressure at random, and then from actual values of the total heat at these pressures, and for various amounts of superheat, the corresponding slope lines gave intersections through which the curved superheat lines were drawn. The curves for entropy are so near those for total heat that one set was found to represent both of these properties with a very close degree of accuracy. A separate set of curves, however, had to be constructed for volume, and to avoid confusion a second diagram was drawn at D for volume.

Solution of Various Problems, Showing the Use the Chart

The following problems, worked out in detail, will show the use of the chart and at the same time explain the methods of solving various important questions concerning the generation and use of steam. The values given in parenthesis at the end of each solution are those worked out from the steam tables of Marks and Davis, and are inserted simply for the purpose of showing the accuracy of the determinations made by means of the chart.

1. Find the heat of the liquid, total heat, and latent heat of vaporization of dry steam at atmospheric pressure, 14.7 lb. per sq.in.

Since the quality of water is zero, the slope line through A to the point where $x = 0$ will be horizontal. The corresponding parallel through the value 14.7 on the curve B intersects the vertical Total Heat axis at 180, which indicates that the heat of the liquid is 180 B.t.u. The quality of dry saturated steam is 1.0; so, if a slope line is drawn through A to the point where $x = 1.0$, a parallel to this slope line drawn from 14.7 on the curve B will intersect the Total Heat axis at 1150, which indicates that the total heat of dry steam at 14.7 lb. is 1150 B.t.u. The difference between the two values thus found is 1150 — 180 = 970 B.t.u., which is the latent heat of vaporization required.

(180; 1150.4; 970.4)

2. How much heat is required to make steam at 185 lb., gage, primed 5 per cent., from feed water at 150 deg. F.?

A pressure of 185 lb., gage, is equivalent to approximately 200 lb., absolute, and if the steam is primed 5 per cent., the quality is 95 per cent., or 0.95. To find the total heat in a pound of steam of 0.95 quality and 200 lb. pressure, a slope line is drawn through A to the point where $x = 0.95$, and a parallel to this slope line is drawn through the 200-lb. point on the curve B. The parallel cuts the vertical Total Heat axis at 1160; then the total heat is 1160 B.t.u. The heat in a pound of feed water (which has a quality of $x = 0$) is found by drawing a horizontal line through the 150-deg. point on the curve B. This horizontal cuts the Total Heat axis at 120, indicating that the feed water contains 120 B.t.u. per lb. above 32 deg. The heat required

to make 1 lb. of steam, therefore, is 1160 — 120 = 1040 B.t.u.

(1155.9; 117.9; 1038)

3. If steam at 200 lb., absolute, is superheated 250 deg. F., what is the total heat per pound, the actual temperature, and the volume?

As the steam is superheated, the slope line will lie in that part of the chart designated as the Superheated Region. The slope line for finding the total heat is drawn from *A* to the point in the diagram *C* where the horizontal 200-lb. line cuts the 250-deg. cross-line. The parallel is drawn from the point indicating 200 lb. on the curve *B* and cuts the Total Heat axis at 1330; that is, a pound of steam at 200 lb., superheated 250 deg. F., contains 1330 B.t.u. The temperature of saturated steam at 200 lb. is read from the curve *B* directly opposite the point indicating 200 lb. pressure, and is 382 deg. The temperature of the superheated steam is then 382 + 250 = 632 deg. F. The slope line for finding the volume is drawn from *A* to the point in the diagram *D* where the 200-lb. horizontal line cuts the 250-deg. cross-line. A parallel to this slope line, drawn from the 200-lb. point on the horizontal Pressure-Volume line cuts the vertical Volume axis at the point 3.2; that is, the volume of 1 lb. of the superheated steam is 3.2 cu.ft. (If it is remembered that the values on the right-hand side of the Volume axis correspond to the pressures on the upper side of the horizontal Pressure-Volume line, there will be no danger of reading 32 cu.ft. from the vertical Volume axis instead of 3.2 cu.ft.)

(1332.4; 631.9; 3.21)

4. If the steam in problem 2 is passed through a throttling valve and the pressure is reduced to 60 lb., what will be its quality?

Throttling is an action in which the total heat remains constant. According to the solution of problem 2, the point 1160 on the Total Heat axis represents the total heat of the steam before it is throttled. After it is throttled, its pressure is only 60 lb. Therefore, a line is drawn from 1160 on the Total Heat axis to 60 lb. on the curve *B*, and a parallel to this line is drawn through *A*. This parallel through *A*, which is the slope line of the throttled steam, cuts the Quality axis at a point where $x = 0.98$; consequently, the steam after throttling has a quality of 0.98, or contains 2 per cent. of moisture.

(0.978)

5. If a throttling calorimeter, exhausting at 14.7 lb. pressure, has a temperature of 268 deg. F., what is the priming in the steam, if the initial pressure was 150 lb., absolute?

The first step is to find the total heat of the steam. The calorimeter pressure, 14.7 lb., is not shown in the diagram *C* on the chart, and so the heat of superheat must be calculated. The temperature increase is 268 — 212 = 56 deg., and so the heat of superheat is 0.47 × 56 = 26 B.t.u. From problem 1, the total heat at atmospheric pressure is 1150 B.t.u., and so the steam has a total heat of 1150 + 26 = 1176 B.t.u. per lb. Then, from the point 1176 on the Total Heat axis a line is drawn to the 150-lb. point on the curve *B*, and parallel to it a slope line is drawn through *A*. The slope line cuts the Quality axis at 0.98, indicating that the steam is 98 per cent. dry, or contains 2 per cent. of moisture.

(1.9)

6. Find the values of the entropy and volume per pound of the steam in problem 2.

The slope line is drawn to $x = 0.95$, and the parallel is drawn from the 200-lb. point on the Pressure-Entropy curve *E*. This parallel intersects the vertical Entropy axis at 1.5, indicating that the entropy is 1.5. A parallel to the same slope line, drawn from the 200-lb. point on the horizontal Pressure-Volume line, will cut the vertical Volume axis at 2.2, indicating that the volume per pound is 2.2 cu.ft.

(1.4955; 2.175)

7. If the steam of problem 2 expands adiabatically to 2 lb., absolute, what are the values of the final quality, the drop in total heat, the final volume, and the ratio of expansion?

During adiabatic expansion the entropy of the steam does not change. The procedure, therefore, is to find the entropy of the steam at the initial pressure, and using this point on the Entropy axis as a pivot, to swing the parallel to the new pressure, 2 lb., and then to draw a new slope line parallel to the parallel. In the solution of problem 6 the entropy of the steam was found to be 1.5. From the point 1.5 on the vertical Entropy axis a line is drawn to the pressure of 2 lb. on the curve *E*. A slope line through *A* parallel to this line will give a value of $x = 0.76$, or a quality of 76 per cent. Another line parallel to it, from the 2-lb. point on the curve *B*, will cut the Total Heat axis at 870, indicating a total heat of 870 B.t.u.; and a third parallel from the 2-lb. point on the horizontal Pressure-Volume line will cut the vertical Volume axis at 132, indicating a volume of 132 cu.ft. per lb. The total heat of the initial steam, according to problem 2, is 1160 B.t.u., and so the heat drop is 1160 — 870 = 290 B.t.u. The initial volume, by problem 2, is 2.2 cu.ft., and so ratio of expansion is 132 ÷ 2.2 = 60.

(0.757; 289.9; 131.3; 60.2)

8. A closed tank contains 12 lb. of dry steam and 4 lb. of water at a temperature of 300 deg. F. Find the pressure, and the volume of the tank. If the temperature falls to 150 deg. F., find the resulting pressure, and the new quality of the mixture.

The initial mixture consists of 16 lb. of steam and water, of which 12 lb. is steam; so the quality is 12 ÷ 16 = 0.75. The temperature is 300 deg. F., and so the corresponding pressure, read directly from curve *B* opposite 300 deg., is 67 lb. From the 67-lb. point on the horizontal Pressure-Volume line a parallel to a slope line indicating 0.75 quality will cut the vertical Volume axis at 4.9; that is, the volume of the mixture is 4.9 cu.ft. per lb. As the tank contains 16 lb. of mixture, the total volume must be 4.9 × 16 = 78.4 cu.ft. While the temperature falls to 150 deg. the volume remains unchanged, and the pressure falls to 3.75 lb., as the point 3.75 on the pressure side of curve *B* corresponds to 150 on the temperature side. Consequently, from 4.9 on the Volume axis a line is drawn to 3.75 on the horizontal Pressure-Volume line. A slope line through *A* parallel to this line will cut the Quality axis at 0.05; therefore, the quality of the mixture at 150 deg. F. is 0.05.

(67; 78.7; 3.714; 0.05)

Operating Conditions in Diesel Engine Plants

By E. E. Snow

Steam-plant operation may be said to be fairly well standardized. At present there are but few questions of proper steam pressures, vacuum and condensing-

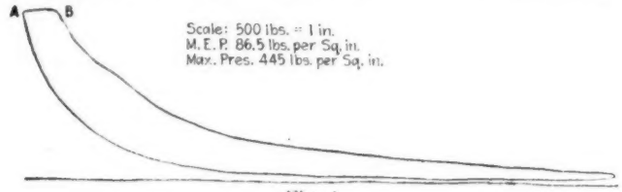


Fig. 1

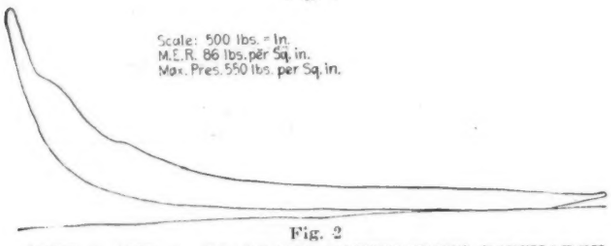


Fig. 2

FIGS. 1 AND 2. DIAGRAMS TAKEN WITH DISCHARGE WATER AT 125 AND 150 DEG. F., RESPECTIVELY

water temperatures, as applied to the average steam plant, that have not been solved.

Unfortunately, the reverse is true as regards operating conditions in Diesel-engine plants. Such problems as air-injection pressure, lubrication and cooling-water temperatures are still subjects of discussion. The matter of the temperature of cooling-water discharge is probably the most important. It should be recognized by the operator that the temperature carried must be governed by the character of fuel oil used. In some plants there is a tendency to carry a discharge temperature as low as 120 deg. F., even if the oil is a heavy residuum; in other plants burning a high-gravity distillate, the discharge is often carried at 160 deg. F. It is needless to remind the experienced operator that low temperatures with heavy oils will cause a smoky, foul exhaust. The disadvantage of high temperature with distillate oil is not so generally understood.

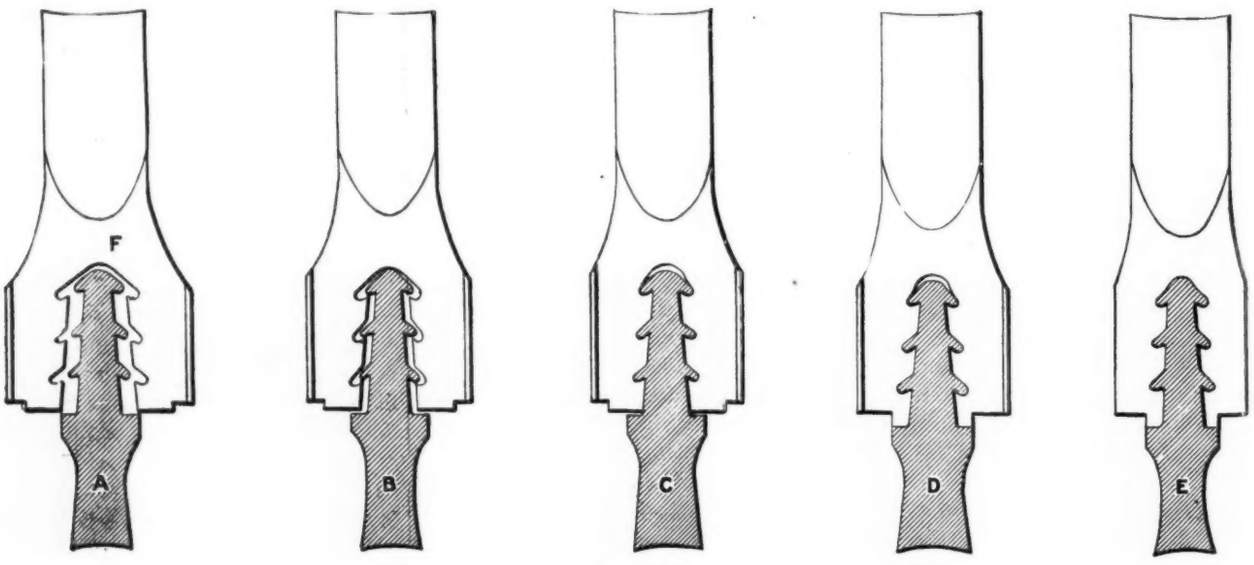
Attention is called to the two indicator cards. Fig. 1 was taken from a Diesel when the cooling-water discharge was 125 deg. F. This card, in respect to the combustion line *AB*, is almost ideal. When the card in Fig. 2 was taken, the temperature of the discharge was allowed to reach 150 deg. F. Since a light distillate was being burned, this high temperature (due to insufficient water) caused the entire cylinder, including the fuel valve, to become hot. The fuel, since it was very thin and volatile, issued from the fuel valve when the latter was opened and immediately the entire charge ignited. This produced a decided rise in pressure above the compression pressure; in many respects this card has the appearance of an Otto-cycle or constant-volume card.

Undoubtedly, this sharp increase in pressure places the engine under a strain not contemplated by the designer. Possibly this high-temperature condition explains an occasional fractured cylinder head or ruined bearing. To all outward appearances the engine was operating under no unusual condition. This is but additional proof that the Diesel engineer needs an indicator and should not neglect to use it nor to learn to analyze what it shows.

Fixing Turbine Blades

A French patent recently granted to the *Aktiebolaget Ljungstroms Angturbro* describes the method of fixing turbine blades and is shown in the accompanying illustrations.

The periphery of the supporting disk, shown cross-hatched in the illustrations, is fashioned with projections as shown, and the bases *F* of the blades are recessed to receive such projections. The recess is initially wide enough to allow the blade to be slipped on over the rim of the disk into the position shown at *A*, and by lateral pressure applied to the base of the disk it is closed successively to the positions and forms shown at *B* and *C*. The shoulder upon the base of the blade is then driven up to the shape indicated by *D*, closing the joint tightly between the shoulder of the disk and the heel of the blade, and a final lateral pressure completes the job, as shown at *E*.



SHOWING METHOD OF SECURING TURBINE BLADES

EDITORIALS

Alcohol as Motor Fuel

INCREASED demands for gasoline with accompanying increase in price have again directed attention to the utilization of substitutes, particularly alcohol, as fuel for internal-combustion motors. The supply of petroleum is limited, and as this limit is approached the price is certain to advance still more, it having doubled during the past six years in this country and more than doubled abroad. On the other hand, the supply of alcohol from vegetable matter is practically inexhaustible, and the sooner it comes into general use for power purposes the longer will the gasoline supply be conserved.

Heretofore the restricted use of alcohol has been due to its inability to compete in price with gasoline, this handicap having been intensified by governmental restrictions. Whether the point has now been reached where successful competition is possible, is a matter for investigation.

The British government, viewing with concern the rising price of gasoline, last November appointed a committee to inquire into the production and utilization of alcohol as a motor fuel. This committee has recently submitted its report. It found that while alcohol is obtainable from molasses, potatoes, wood pulp and other vegetable products, the yield, contrary to popular opinion, is not large; that from potatoes, for instance, being only twenty gallons per ton. It can also be produced synthetically from coal and coke-oven gas, but the most promising source appears to be from tropical plants of which the sun-dried flowers of the mahua tree will yield ninety gallons per ton.

The usability of alcohol in internal-combustion engines with a properly designed carburetor and slightly modified compression is well recognized, so that there is no obstacle from the engineering standpoint. It is purely a commercial problem. Owing to the somewhat lower heat value of alcohol a correspondingly greater quantity must be used per horsepower-hour, so that in order to compete with gasoline the cost per gallon must be proportionately less.

As a means of keeping down the cost the committee recommends that the British government modify the restrictions concerning the storage and distribution of alcohol, consistent with the prevention of its improper use—a recommendation that might well be given serious consideration in this country. It reports further that, while not definitely committed to the idea that the time has arrived when alcohol can compete commercially with gasoline, it believes nevertheless that such time is not far distant and strongly urges that steps be taken by the British government to carry on such investigations and give such support to the alcohol industry as will put it on its feet to meet any further increase in the price of gasoline.

While true that the motor-fuel situation is much more acute in England than in this country, yet would it not be well for this Government to profit by the recommendations of the British committee and by a little forethought through investigation avert a possible crisis a few years hence?

Some eight or ten years ago an effort was made to interest the farmer in the utilization of farm refuse for the production of alcohol on a small scale. To this end certain restrictions were removed, as applied to farms only, and the Department of Agriculture issued instruction pamphlets. The response to this effort, however, was small, perhaps owing to the then low price of gasoline and to the fact that the farmer at that time was not a large user of internal-combustion engines. But that condition has changed, the farmers now have their automobiles and are large users of internal-combustion engines to drive the various farming implements. Perhaps a renewal of the former efforts would now bring results.

Boiler Inspection and Engineers' License in Massachusetts

THE legislature of Massachusetts has consolidated the one hundred and odd commissions and divisions of the state government into twenty departments. The District Police Force, the Board of Boiler Rules, the Board of Elevator Regulations and the Fire Prevention Commission of the Metropolitan District are to be abolished and all their rights, powers, duties and obligations transferred to a Department of Public Safety under the supervision and control of a commissioner appointed by the governor for a term of five years at a salary not to exceed five thousand dollars per annum. The law goes into effect so far as each department is concerned upon the appointment and qualification of the officers having the supervision and control thereof, but not before the first day of December of this year.

The Department of Public Safety is to be organized in three divisions—a division of state police under the immediate charge of the commissioner, a division of fire prevention under the charge of a director to be known as State Fire Marshal, and a division of inspection under the charge of a director to be known as the Chief of Inspection. These directors are to be appointed for three-year terms and to receive such salaries, not in exceses of four thousand dollars per annum each, as the governor and council may determine.

The Board of Boiler Rules is to be reconstituted, to consist of the Chief of Inspection as chairman and four other members appointed by the Commissioner of Public Safety, their qualifications and compensation to be the same as those of the members of the present board.

The functions of the boiler inspection department of the district police, including the examination and licensing of engineers and firemen, are to be exercised by the division of inspections, which will also take over the work of the building inspection department.

To be the chief of the inspection division of a state department of public safety offers a large opportunity for a large man. It would require a high degree of versatility, a broad experience and a comprehensive training to deal in detail with such diversified subjects

as the safe design, construction and operation of boilers and pressure vessels and the subjects handled by a building department. The problems are all of an engineering character, and the ideal director would be an engineer of large directive and executive capacity. Even such a man would have to depend largely upon the specialists in the different departments or be swamped in a mass of detail. He should have a keen appreciation of the importance of this trust, a vision of the possibilities of such a department, engineering enough to devise means and prescribe methods for guarding the public safety, and executive ability enough to get them applied. The bill specifies no qualification for the holder of the office, and much will depend upon the good judgment and freedom from political influence of the governor who makes the selection.

Under the new law no provision is made for any head of each of the two subdivisions of the inspection division. There is nobody, for instance, between the men who do the actual inspecting of boilers and the examining of engineers and firemen for license and the director who is the head of the building inspection as well. This can be gotten around by detailing an inspector of sufficient experience and ability to do such technical inside work as has brought the department to such a high degree of efficiency under the administration of the present incumbent and his predecessors.

It is unfortunate that the organization as planned is not a permanent one. The work is highly specialized and such that the value and efficiency of the man who is doing it grows with experience and continuity of service. Frequent turnover and uncertainty of tenure are not conducive to economical administration nor to the production of the best results. Work in such a department should offer a man a life's career. One ought to be able to progress from inspector to Chief of Inspections and to Commissioner of Public Safety without fear of disturbance by political changes and without using a large part of his time, energy and interest in keeping his job instead of doing it as it ought to be done.

The success of the new Department of Public Safety will depend upon its personnel. We shall watch its progress with interest.

Interest in Power-Plant Performance

TIME was, not so long ago, when a man's ability to get uninterrupted service from a plant was the highest asset he could attain. This was true of the whole power-plant crew. The fireman who could keep the pointer on the steam-pressure gage at the right figure was a treasure. Those who have had the pleasure of firing a moderate or large power plant remember that the old fellow who was dean in the boiler room commanded the respect of all hands. Of course such a man as "the dean," let us call him, usually secured good performance results measured in terms of coal and water evaporated. But it was because he could keep the pressure up where it belonged that he was admired, just as the engineer who could keep the wheel turning was highly regarded.

The situation in this regard is unchanged today. But more has been added to the requirements of the engineer and his crew. Besides giving uninterrupted service, he must get the most economical performance of which the plant is capable. Today there are indeed many yardsticks by which to measure a plant's performance, considered as a unit and also compared with what other similar well-operated plants can do. As King Alexander's tutor told him there was no royal road to algebra, so, too, must power-plant men understand that there are few if any short cuts to good power-plant performance. To get it requires a knowledge not only of fundamentals and principles, but of the many practical aspects of operation and management, with its market values, and accounting.

The modern power-plant engineer of big proportions must of necessity be much more of a business man than his fellows of yesterday ever dreamed of being.

Engineering Preparedness

SOME time ago *Power* was asked to recommend a man who could keep the power plant in a large factory going. Work was interrupted, production reduced and the force disorganized by frequent shut-downs. We sent them a man who stopped the trouble; not by taking reckless chances in keeping the plant running when another would have shut it down, but by preparedness. He has probably, in thought and in imagination, been through most of the troubles that could possibly occur to mar his record of continuous performance, has foreseen and headed off many, and prepared to grapple with those that he could not prevent.

The first few moments when trouble manifests itself are the critical ones. A masterful man keeps his head, knows just what to do and has things ready to do it with, as though he were expecting it. His crew responds with confidence, bears his coolness and gets out of it with the least fuss and damage. What would you do if:

The water suddenly failed—if the packing blew out of a joint on the steam main—if coal was received for which the grates were not fitted to burn—if the men struck—if the central station solicitor came in—if the boss wanted to know how much it was costing to run the plant—if you had but one feed pump and it broke down—if an engine frame cracked—if the rear arch of a return-tubular boiler fell in during running hours—if the boiler was burned badly—if a blowout pipe became clogged with scale or mud and the boilers had to be kept in operation to prevent a shut-down?

In fact, what would you do in case any of the hundreds of possible accidents that occur in power plants should occur in yours?

Senator Lenroot has introduced a bill to provide for the leasing of coal deposits owned by the United States outside of Alaska. The major condition of any such lease or concession should be that the coal produced be sold to the public at a fair profit upon the actual cost of mining it and that such cost include no interest upon intangibles based upon ownership or privileges under such concession other than expenditures actually made in the obtaining and maintenance of the lease or concession and of the prospecting and other actual work done upon it—in other words, actual cost which involved the expenditure of real time and money.

Plans are under discussion for a great international exposition to be held at Boston to commemorate the three-hundredth anniversary of the Landing of the Pilgrims. It is proposed that the exposition shall be entirely different from the ordinary world's fair, including only the finest exhibits pertaining to science, art, education, religion, industry and commerce.

Correspondence

Loose Bearing Caused Induction Motor To Fail To Start

After repairing a large three-phase induction motor, an attempt was made to put it back into service. On closing the compensator switch to the starting position, the motor failed to start, although it was evident from the sound of the machine that it was getting current through its winding. The first thing that suggested itself was an open circuit, so the starting compensator was tested to see if the current was coming through single-phase only. In order to do this quickly, we disconnected the motor lead at the machine, and while the switch was held on the starting position a test lamp was connected across the different leads, as in Fig. 1. This showed current on each phase, at a reduced voltage, of course. We then put the switch on the running position and the test lamp burned brightly across each phase, showing that the motor was getting the current all right.

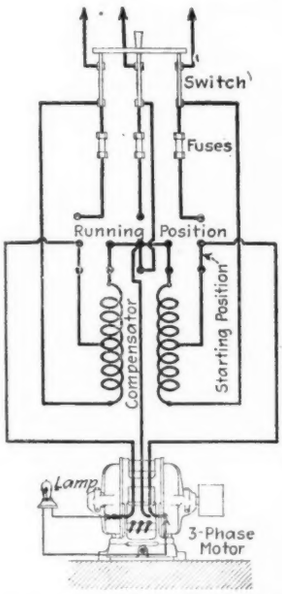


FIG. 1. METHOD OF TESTING FOR OPEN-CIRCUIT

The rotor seemed to be rubbing a little on the stator, as it was somewhat hard to turn, so the clearance was adjusted by means of two draw-bolts on the bearing housings. This took some time, since when the bearings were moved one way a little, the rotor would bind; then we would shift it back slightly until finally getting it into a position where the rotor turned freely. Another attempt to start motor met with no better result than the first. The next step was to trace out the winding connections, which were found to be apparently correct. The winding being connected two parallel star made it somewhat complicated to trace out. However, by looking to see if the connections went under or over the winding, I would mark an arrow on the group of coils to show the polarity. We went around each phase in this way, starting with the outside lead in each case. The arrows on each group pointed alternately in opposite directions, showing the connections to be correct, as in Fig. 2.

The next suggestion was to test the polarity of the winding with a compass, when direct current was flowing through the coils. As a source of direct current an automobile starting and lighting battery was pressed into service. The three motor leads, *A*, *B* and *C*, Fig. 2, were joined together and connected to one terminal of the battery. A wire from the other battery terminal was taken to the common or neutral point on the winding, where the three phases connected together, such as *A**, *B** and *C**, Fig. 2. This connection was not attached permanently, as it would have run the battery down, owing to the low resistance of the circuit through the winding, but was attached each time only while the swing of the compass opposite each group was obtained. This test proved the connections to be correct, as the compass needle pointed in opposite directions on alternate groups as it was moved around the winding.

Since the polarity of the coils was undoubtedly correct, it left us all puzzled as to the cause of the trouble, as we had tested for grounds in the winding, open circuit, polarity, tested for the power at the motor terminal, and also mechanically, to see that rotor was free.

We had about decided to give the job up and send the machine to the manufacturers to have it fixed up, when one of the engineers came in on the job and after hearing our story remarked that the motor had given similar trouble, two or three years previous, after being repaired, due to the bearing letting the rotor rub on the stator. This gave us an idea that there might be a slight looseness in the bearing, sufficient to let the rotor lift up and rub on the stator. Acting on this, the bearing bolts were adjusted until the rotor would just clear the bottom of the stator. This proved to be the source of all the trouble; on closing the compensator the motor started up and ran satisfactorily, greatly to the relief of everybody concerned.

Toronto, Ont., Canada. H. WILSON.

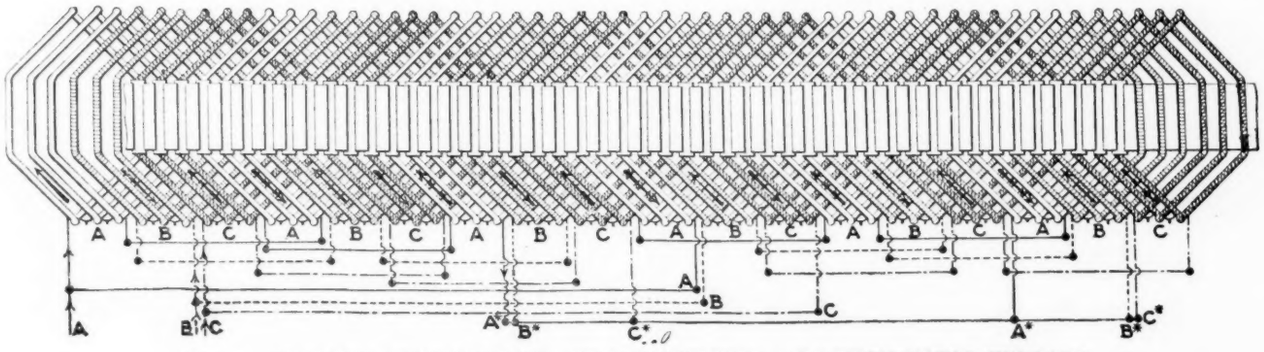


FIG. 2. SIX-POLE, TWO-PARALLEL, STAR-CONNECTED INDUCTION MOTOR WINDING

Needed Improvements in Boiler Construction

The account in your issue of Mar. 25, 1919, of a double boiler explosion at Mobile and the more recent one at Newmarket, Ont., brings to mind some opinions that I have held for many years. In a paper that I read before the American Society of Mechanical Engineers[1] a few years ago, I took the ground that the spherical heads of steam drums should not be given much credit for strength and that they should be stayed

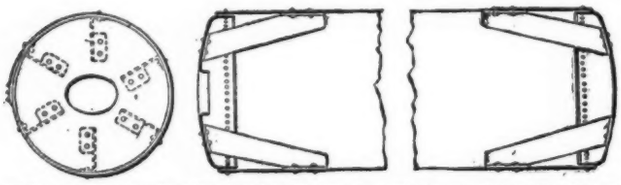


FIG. 1. DRUM HEADS STAYED BY RADIAL GUSSET PLATES

by radial gusset plates strong enough to take the whole load. A way to do this is shown in Fig. 1. The reason for this view is that the stresses in these heads at the edges cannot be computed, that they are not wholly in a state of equilibrium and that they therefore "breathe" and tend to disintegrate and crack along the edges. The disintegration promotes corrosion. Any insurance company will testify to numerous cases of partial injury around the edges of drumheads, and from the many cases of rupture it seems to me that it is time that drumheads should be considered dangerous unless they are stayed like flat heads.

Many designers of steam boilers appear to think that if they put a spherical head in a drum having a radius equal to the diameter of the drum, a thickness equal to or greater than that of the drum shell and a fairly good-sized radius at the corner, they have done their duty. I do not think that they have and believe that they should discontinue the practice. I should much prefer heads of suitable thickness dished inward, although nobody uses them. There is no more

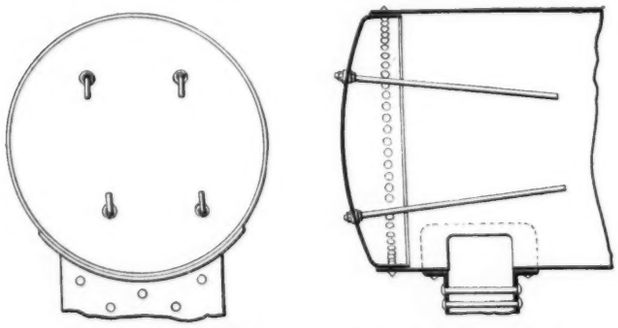


FIG. 2. TRANSVERSE HEADER CONNECTION TO LONGITUDINAL DRUM

reason for being afraid of them than for being afraid of corrugated furnaces, nor, in fact, so much. It should not be forgotten that the manhole openings are a serious cause of weakness and that sometimes they have been pushed out.

In my opinion there are several partly digested features of water-tube boilers, and among them are the manners in which drums and headers are cut into for various purposes. A designer should carefully consider whether any part of his design can move back and forth with changes in pressure. Changes in pressure are very frequent, and if any part can bend with such changes, a potential cause of rupture exists.

If a transverse header is connected to a longitudinal drum so as to considerably cut the latter off, as shown in Fig. 2, there is likely to be a rupture, even if there are longitudinal ties riveted to the shell, for they may not be firmly riveted and no dependence should be placed upon them. Neither should any dependence for making up this strength be placed upon stay-bolts of the water-leg being placed close to the drum. Longitudinal tie-rods should not be used because they may not take their load until after the drum has been overstressed from the steam pressure acting on the ends of the drum.

The best way to provide communication is to penetrate the drum by the smallest practicable number of small holes, or to make some with flanges and pressed inward,

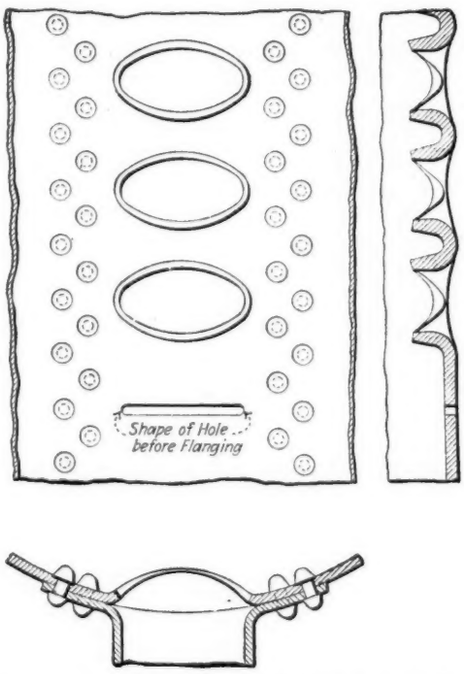


FIG. 3. SMALL HOLES PRESSED TO LARGE FLANGE OPENINGS

as shown in Fig. 3, as is done in one make of water-tube boiler. Better still, longitudinal drums should be abandoned and cross-drums used.

A feature of many of the designs of cross-drum marine water-tube boilers is the cutting of many holes in the drum for accommodating a row of nipples at the bottom and one or two rows of circulating tubes on the side. When this is done, it is common to rivet on a reinforcing strap inside, like *A*, Fig. 4. This strap should, however, always be riveted to the outside of the drum like *B*, and be made a metal-to-metal contact with it if such a thing is possible in the art of boiler-making.

The tube holes in the strap should be larger than those in the drum, and the tubes should be expanded only in the drum plate. It is necessary to design the outside strap with the outer rivets far apart in order to have a joint of high efficiency, and to do this and be able to calk the strap it is necessary to resort to the saw-tooth joint. If the strap is placed on the inside, pressure will get between it and the drum if it is

[1] "Transactions A. S. M. E." Vol. 37, p. 627.

not calked and probably if it is, and it becomes a series of bent ties between rivets and never can help the main plate until the latter is overstrained. If the outside strap could be used without calking, it would be more effective, and this can be done if the rivets are reliably calked inside. If pressure gets between plates the inside one, even if it is the shell, is thrown out of equilibrium and bends between rivets.

Better still, however, drums should be so thick that they will not require reinforcing where penetrated, and the longitudinal joints should be placed where they will

FIG. 4. INSIDE REINFORCING STRAP A WRONG

not be penetrated. In such construction the longitudinal joint would generally be one of low efficiency; possibly it would be a single-riveted double-strap butt joint.

Here again, as many times before, I want to advocate the abandonment of the prevailing form of butt joint used in the country namely, that of having a wide inside, like *B*, Fig. 5, in order to minimize bending and Such a joint means bending of plates, with variations in pressure, and such alternate bending may mean explosions. While joints with straps of equal widths and all rivets in double shear should always be used, if the one-sided joint is used the wide strap should be outside, like *B*, Fig. 5 in order to minimize bending and promote the effective assumption of the load. In this case it would be an easy matter to calk both the inside

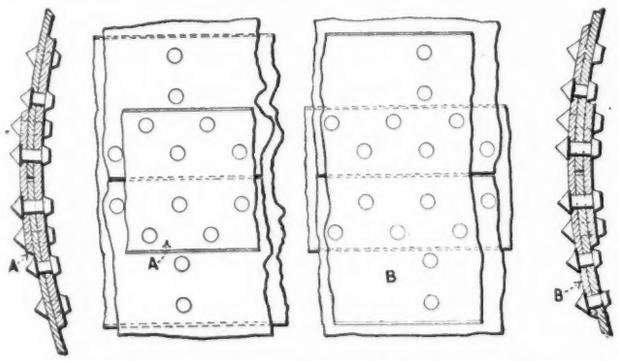


FIG. 5. NARROW OUTSIDE STRAP A MEANS BENDING OF MAIN PLATES

strap and the rivets and leave the outside strap uncalked.

Everything should be done to prevent any part of a boiler from bending, and this is a principle that every designer should keep constantly in view. When a boiler is designed so that this principle is realized and good material and workmanship are employed, explosions will all but disappear, and this is the moral of this letter.

The motto of the boiler designer should be, "Avoid transverse stresses, especially if they are alternating."

Boston, Mass. F. W. DEAN.

Reclaiming an Old Heating System

In a plant that I recently visited, I found a very unusual improvement in operation on a vacuum heating system. This plant consisted of several widely scattered buildings of varying heights and types of construction. The system in use took the exhaust steam from the main engines through the radiators into the return lines, through common globe valves instead of automatic vacuum valves. These valves were left wide open to be sure that no water stayed in the coils and this, together with long, leaky return lines, made it impossible for the vacuum pump to do good work without adding an excessive amount of cold water to condense the steam, which was later thrown away, as it could not be used.

As the chief engineer could not get an appropriation to put in about 200 return valves and renew the return lines, which would have cost close to $2000, he did the next best and obtained authority to buy a closed heater, which he did. This heater was connected to the main return line near the pump so that the returns would occupy the regular steam space. The feed water for the boilers passed through the coils, then to the main heater. With water from the city mains at from 45 to 60 deg., a 5-in. vacuum was easily maintained by this heater surface condenser without the addition of cold water.

While at first glance this appears to be a crude roundabout way of accomplishing an object, there are several advantages: First, a good active circulation in the heating system is assured; second, there is a saving in heat and water, as no cooling water is added to be thrown away; third, cold water entering this heater leaves at from 70 to 110 deg., going to the main heater, where it is heated to a temperature never before attained and resulting in a marked saving in coal; fourth, by sending warm water into the coils of the main heater instead of the icy water of former years, there is much less condensation on the coils and consequently the heating system receives much drier steam.

Instead of an outlay of from $1500 to $2000 and much disturbance throughout the buildings, this method cost about $500 with no disturbance and a marked improvement in boiler efficiency. H. K. WILSON.

New Bedford, Mass.

Peening Stopped Leak

Recently, when about to brush the tubes of a boiler a steam leak was discovered at the joint of the front 12-in. nozzle. An examination showed that the leak was at the threaded joint.

Although the pressure carried never exceeds 80 lb., the leak, if neglected, would have grown worse, therefore I suggested putting in a new nipple. This would have entailed considerable expense, as all the joints to and including the one at the main are screwed. The department inspector sent a steamfitter to look into the matter. He told me he would first try peening on the inside as a remedy before resorting to a more radical measure. This was done by using a light ball-peen hammer on the joint on the inside, for fully two hours.

The boiler was used eight months this last winter with no sign of a leak. A. DOLPHIN.

Jamaica, N. Y.

Don't Take Chances with the Synchronoscope

On page 650 of *Power*, May 29, Mr. Gillooly wrote about taking chances with synchronoscopes. Further comments on this practice may be of interest, since the subject is an important one and one about which there is comparatively little in print.

Synchronoscopes should always be checked before use. If all connections are correct and the synchronizing plug is inserted, the instrument pointer invariably gives a kick. Synchronizing lamps are generally used as well as a synchronoscope, and the indication and functioning of the former should be watched in conjunction with the synchronoscope.

Failure of any of the lights to burn indicates a burnt-out lamp or an open circuit. If the lights operate correctly while the synchronoscope does not, it is often safe to synchronize by the lamps, provided the man doing the synchronizing is familiar with the speed at which the switches operate, the characteristics of the machines and the system upon which it operates.

The writer investigated one job where it was impossible to synchronize by the synchronoscope, and it was found that the instrument pointer was 180 deg. out of phase. Watching the lamps after checking up the instrument wiring brought the true state of affairs to light. In choosing between synchronizing with lamps out or at full brilliancy, the former will be found the more preferable, as it permits of closer judgment by the eye.

To synchronize two alternating-current machines for minimum current flow at time of tying the machines together, there must be equality of terminal voltage between the machines, they must be operating at the same frequency, and they must be in phase. The synchronoscope indicates the latter quite accurately, but some instruments are not very sensitive to voltage difference. While voltage difference is the least important of the three requirements for synchronizing, nevertheless terminal voltage should be checked before paralleling the units.

Failure of synchronoscopes to work is generally due to broken wires, the instrument sticking, blown transformer fuses at the instrument's transformers, burnt-out lamps or lamps loose in their sockets. Faulty synchronizing plugs sometimes give trouble and cause delay.

There are several good schemes in use for utilizing the synchronoscope in certain special ways. Sometimes generators are protected by overload relays only during the time that the machines are being synchronized. In this way a machine is protected against bad synchronizing. This is easily accomplished by connecting the overload trip circuit through the synchronizing plugs, so that the circuit that trips the oil switch is energized through the overload relays only while the synchronoscope plugs are in circuit.

Another practice that is sometimes employed in stations having a large number of machines is to wire the control circuit for closing the generator circuit-breaker so that it cannot be closed unless the synchronizing plug is in the receptacle corresponding to the generator to be synchronized. In this way a station attendant cannot start to synchronize one machine and by mistake close the circuit-breaker of some other machine that is standing idle.

B. M. SMITH.

Cicero, Ill.

Making Each Coil of An Ammonia Condenser Do Its Share

In the May 27 issue under the heading, "Making Each Coil of Ammonia Condenser Do Its Share," A. G. Solomon has an interesting and valuable article. I have for the last two years been experimenting along the lines suggested by Mr. Solomon. In regulating the water to the double-pipe condenser, the efficiency has been surprisingly increased by maintaining as nearly as was possible a uniform supply of water to the condenser.

I have also observed a few changes that have a serious effect on the efficient operation of the refrigeration plant. Sometimes, shortly after the supply valves to the separator condensers have been set, the rise in temperature of the outside atmosphere will have its effect on the operation; and also, any change in the water pressure in the main supply pipe (particularly when the pressure is reduced) will have a serious effect on the efficient operation of a refrigeration plant. A change in pressure is liable to take place shortly after the valves have been set.

The plant I have experimented with receives its supply from the city mains where the pressure varies from 50 to 60 lb. and by installing a pressure-reducing valve adjusted to maintain a uniform pressure of 40 lb. it was possible to greatly improve the operating conditions. By operating under the automatic regulation of pressure, the valve can be set to supply the condensers and it is not necessary to make any change in resetting the valves unless there is a marked changed in the temperature of the atmosphere or water supply.

Buffalo, N. Y. T. SUTCLIFFE.

Flywheel Explosion at St. Louis

Mr. Dixon's remarks on page 699 of the May 6 issue, regarding the flywheel explosion in a rolling mill, is of interest to me, as I was employed in the mill at the time the engine was first erected and started. As he states, it was an automatic cutoff type and ran as such for a short time after it was put in operation. Trouble with the governor soon developed, however. One evening, just at the time of changing the shift, was, I believe, the first time it ran away. I was standing at my locker door. Everything was serene, when the engine began to race and the throttle was reached barely in time to avert disaster.

From that time on, during my connection with the engine, we ran it on the throttle altogether. I was in no position of authority at the time, but being curious as to why the governor should act the way it did, I wrote to the manufacturers of the engine for a book of instructions. On checking up the valve and governor setting, I found that the governor mechanism was assembled in the wheel, in the position it should have been for running in the opposite direction, which explained its action. The master mechanic in charge at that time had a very decided mind of his own, so my partner and I thought it better to let the engine run the way it was than to start an argument. I am sure that if changes had been made the engine would have operated satisfactorily on its original governor. The throttling governor and shaft pulley Mr. Dixon speaks about were added after I left the plant.

J. A. WATKINS.

Jefferson City, Mo.

Inquiries of General Interest

Inch of Water and Pressure per Square Inch—What is the value of an inch of water pressure expressed in pounds or ounces per square inch? W. D. J.

The pressure exerted per inch of depth of an incompressible liquid is the same pressure per square inch as the weight of a cubic inch of the liquid. A cubic foot of water at standard temperature (62 deg. F.) weighs 62.355 lb., and assuming water to be incompressible, an inch of water pressure is equal to 62.355 ÷ 1728 = 0.03609 lb. per sq.in., or 0.03609 × 16 = 0.5774 oz. per square inch.

Calculating Power Factor—How is the power factor figured from the meter readings of a three-phase alternator? The voltmeter reads 550, the ammeters 360 and the wattmeter 260 kilowatts. M. D.

The kilovolt-amperes (kv.-a.) in a three-phase circuit equals volts × amperes × 1.732 ÷ 1000, in this problem equals 550 × 360 × 1.732 ÷ 1000 = 342.9. Power factor

$$= \frac{\text{kilowatts}}{\text{kilovolt-amperes}} = \frac{260}{342.9} = 0.76.$$

Water Discharged by Blowing Down 1½ In.—What quantity of water is discharged from blowing a 72 in. dia. × 18 ft. horizontal return tubular boiler 1½ in. from a water level 17 in. below the under side of the shell? P. E. M.

The cross sectional area of the steam space may be found by the approximate formula for the area of a segment of a circle. namely,

$$\text{Area of segment} = \frac{4H^2}{3}\sqrt{\frac{2R}{H} - 0.608}$$

where H = the height of segment and R = the radius of arc. When the height of the steam space is 17 in. and 2 R is equal to 72 in., by substitution in the formula the cross sectional area of the steam space would be

$$\frac{4 \times 17 \times 17}{3}\sqrt{\frac{72}{17} - 0.608} = 733.9 \text{ sq.in.}$$

and when the height is 1½ in. lower, or 18½ in. below the sectional area of the steam space would be

$$\frac{4 \times 18.5 \times 18.5}{3}\sqrt{\frac{72}{18.5} - 0.608} = 862.9 \text{ sq.in.}$$

Hence the cross sectional area of the water discharged would be 826.9 − 733.9 = 93 sq.in. and for 18 ft. length of shell, the volume of water discharged would be 93 ÷ 144 × 18 = 11.62 cu.ft.

The weight of water discharged would depend on its temperature. If the boiler pressure was 100 lb. per sq.in., the temperature would be 338.1 deg. F. At that temperature water has a density of 54 lb. per cu.ft. and the weight of water discharged would be about 11.62 × 54 = 627.48 lb.

Setting Slide Valve With Lead—What is the method of setting the valves of an upright slide-valve engine and how much lead should there be? D. M.

The method is practically the same as for setting the valve of a horizontal slide-valve engine. Remove the steam-chest cover and, with the eccentric fast on the shaft, turn the engine over by hand and find whether the admission edge of the valve overrides the admission edge of the steam port as much for one end of the cylinder as for the other. If the amounts are not the same, they should be equalized by adjustment of length of the valve rod. Then place the engine on a center and set the eccentric to such a position that the valve will give the desired lead opening at the beginning of the stroke, but with the eccentric so placed with reference to the crank that the opening will be increased by turning the engine in the running direction. Next, place the engine on the opposite center and if the lead is not the same, obtain one-half the desired lead by readjustment of the valve rod and one-half by readjustment of the eccentric, repeating these adjustments on one end and then the other until the lead is equalized. The appropriate amount of lead opening depends on the size, design and speed of the engine, and also on the steam pressure and the load to be carried. The lead should be at least enough to obtain full steam-chest pressure in the cylinder at the beginning of the stroke when the engine is running at normal speed, and also as much as may be necessary, in conjunction with compression of the exhaust, to insure sufficient cushioning of the piston for quiet running of the engine.

Reversing a Compound-Wound Interpole Motor—We have a 40-hp. 220-volt compound-wound interpole motor with the armature series-field and interpole windings connected in series and do not see any provision made for reversing the direction of rotation of this machine. What connection should be changed to give a reverse direction of rotation? W. L.

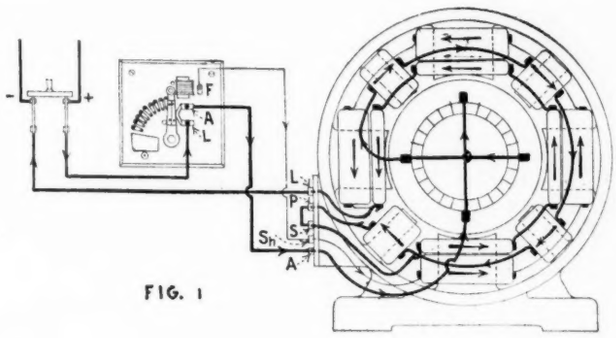


FIG. 1

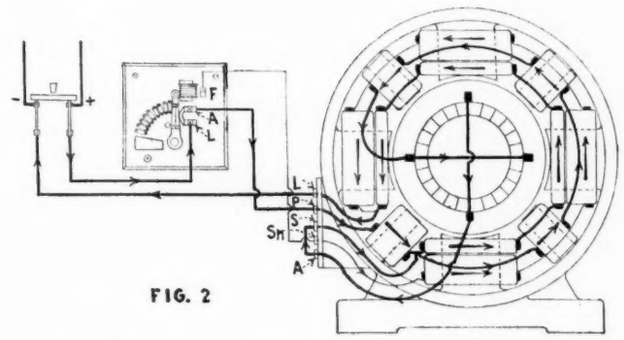


FIG. 2

The direction of rotation of any interpole motor may be changed by reversing the direction of the current through both the armature and interpole windings. If Fig. 1 is the correct connection to give a compound-wound interpole motor one direction of rotation, the connections Fig. 2 are correct for the opposite direction of rotation. It will be seen that the current in the armature and interpole windings in Fig. 2 is flowing in an opposite direction from that in Fig. 1, which was accomplished by interchanging the external wires to the interpole terminal P and the armature terminal A. If the machine is shunt wound, it is generally more convenient to interchange the shunt-field connections to obtain a reverse direction.

The Computation of Combustion Data*

By ARTHUR D. PRATT
Assistant to the Advisory Engineer, Babcock & Wilcox Company, New York City

The methods of computing combustion data and the widely differing data resulting from the combustion of different classes of fuel—that is, the wide variation in possible or probable flue-gas analyses, products of combustion and air supplied per pound of fuel for different combustion conditions—are best illustrated by examples, and these are given.

TYPICAL examples of the different classes of fuel used for the commercial production of heat under steam boilers are considered in the following. Excepting in the case of coal where the analyses vary over a wide range, the analyses of the fuels taken are sufficiently near an average to allow the results to be plotted in such manner that for a given flue-gas analysis (per cent. CO_2) the weight of the products of combustion and the amount of excess air corresponding to such analysis may be determined directly for the specific class of fuel considered with a degree of accuracy sufficient for approximate work.

Mr. Pratt refers several times to the formulas given in what follows:

Formula (4) (Dulong's):

$$B.t.u.\ per\ lb. = 14{,}600\ C + 62{,}000\ (H - \frac{O}{8}) + 4050\ S$$

The symbols represent proportionate parts by weight of carbon, hydrogen, oxygen and sulphur in the fuel; coefficients represent approximate heating values of the constituents with which they appear in the formula.

Formula (27):

$$Pounds\ dry\ gas\ per\ pound\ carbon = \frac{11\ CO_2 + 8\ O_2 + 7\ (CO + N_2)}{3\ (CO_2 + CO)}$$

The symbols represent proportionate parts by volume of constituents of gas.

Formula (28):

$$Dry\ air\ supplied\ per\ pound\ C = \frac{3.032\ N_2}{CO_2 + CO}$$

The symbols represent volumetric percentages; 3.032 is a constant.

Given a coal having the following ultimate analysis: Carbon, 79.86 per cent.; hydrogen, 5.02 per cent.; oxygen, 4.27 per cent.; nitrogen, 1.86 per cent.; sulphur, 1.18 per cent.; ash, 7.81 per cent.; moisture, 2.90 per cent.; B.t.u., per pound, 14,351.

With perfect combustion the oxygen and air required, and the products of combustion per pound of coal, will be as in Table I.

TABLE I. PRODUCTS OF COMBUSTION AND AIR REQUIRED FOR COAL

	Wright per Pound Coal. Pounds	Required Pounds		Products of Combustion Pounds per Pound Coal				
		O_2	Air	CO_2	O_2	N_2	H_2O	SO_2
C	0.7986	2.130	9.200	2.929	.....	7.070	.....	.....
H_2	0.0502	0.402	1.735	.....	.....	1.333	0.452	.....
O_2	0.0427	.....	.....	.....	0.043	.....	.....	.....
N_2	0.0186	.....	.....	.....	.....	0.019	.....	.....
S	0.0118	0.012	0.051	.....	.....	0.039	.....	0.024
Ash	0.0781	.....	.....	.....	.....	.....	.....	.....
	1.0000	2.544	10.986	2.929	0.043	8.461	0.452	0.024
O_2 in Coal.....		0.043	0.186*	.....	0.043	0.143*	.....	.....
		2.501	10.800	2.929	0.000	8.318	0.452	0.024
SO_2 as CO_2....		.....	.....	0.024	.....	.....	.....	0.024
		2.501	10.800	2.953	0.000	8.318	0.452	0.000

*Air and N_2 equivalents of O_2 in coal.

The weight of air theoretically required for the combustion of one pound of coal is then 10.800 lb. For each 20 per cent. in excess of this amount (each 2.160 lb. above 10.800) there will appear in the products of combustion $2.160 \times 0.2315 = 0.500$ lb. O_2 and $2.160 \times 0.7685 = 1.660$ lb. N_2, and the weights of the products of combustion per pound of coal for varying amounts of excess air will be as given in Table II.

TABLE II. WEIGHTS OF PRODUCTS OF COMBUSTION OF COAL

	Weight Products Perfect Combustion	Weight Products—Varying Amounts of Excess Air—Pounds				
		20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent.
CO_2	2.953	2.953	2.953	2.953	2.953	2.953
O_2	0.000	0.500	1.000	1.500	2.000	2.500
N_2	8.318	9.978	11.638	13.298	14.958	16.618
H_2O	0.452	0.452	0.452	0.452	0.452	0.452
	11.723	13.883	16.043	18.203	20.363	22.523

Expressed in terms of percentage weight, these values are given in Table III.

TABLE III. PERCENTAGE WEIGHT, PRODUCTS OF COMBUSTION OF COAL

	Per Cent. Weight Products Perfect Combustion	Per Cent. Weight Products—Varying Amounts of Excess Air				
		20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent.
CO_2	25.190	21.270	18.407	16.233	14.502	13.111
O_2	0.000	3.602	6.233	8.240	9.821	11.100
N_2	70.955	71.872	72.543	73.054	73.458	73.782
H_2O	3.855	3.256	2.817	2.483	2.219	2.007
	100.000	100.000	100.000	100.000	100.000	100.000

Expressed in terms of percentage weight of dry products of combustion these values are as given in Table IV.

TABLE IV. WEIGHT OF DRY PRODUCTS OF COMBUSTION OF COAL, PER CENT.

	Per Cent. Weight Dry Products Perfect Combustion	Per Cent. Weight Dry Products—Varying Amounts of Excess Air				
		20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent.
CO_2	26.200	21.987	18.940	16.636	14.831	13.380
O_2	0.000	3.723	6.414	8.450	10.044	11.327
N_2	73.800	74.290	74.646	74.914	75.125	75.293

If we convert these percentages by weight of the dry products of combustion into terms of percentage by volume, the values in Table IV become as given in Table V.

TABLE V. VOLUME OF DRY PRODUCTS OF COMBUSTION OF COAL

	Per Cent. Volume Dry Products Perfect Combustion	Per Cent. Dry Volumes—Varying Amounts of Excess Air				
		20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent.
CO_2	18.428	15.285	13.057	11.396	10.110	9.085
O_2	0.000	3.559	6.080	7.960	9.415	10.575
N_2	81.572	81.156	80.863	80.644	80.475	80.340
	100.000	100.000	100.000	100.000	100.000	100.000

For the purpose of comparing the results as computed with those obtained through the use of the combustion formulas that have been discussed, assume that the coal is burned with 40 per cent. excess air and the flue-gas analysis by volume shows 13.057 per cent. CO_2, 6.080 per cent. O_2 and 80.683 per cent. N_2.

The weight of dry products of combustion per pound of carbon will be, from formula (27):

$$\frac{11 \times 13.057 + 8 \times 6.080 + 7 \times 80.863}{3 \times 13.057} = 19.359\ lb.$$

Multiplying this value by the weight of carbon per pound of dry coal, we have as the weight of dry products per pound of dry coal,

$$19.359 \times 0.7986 = 15.460\ lb.$$

as against a value, in Table I, of

$$16.043 - 0.452 = 15.591\ lb.$$

an error of 0.131 lb., or 0.84 per cent. If the carbon weight is corrected for the sulphur equivalent (explained on page 54 of the book), the value of C becomes

$$0.7986 + (0.012^1 \div 1.833) = 0.8051$$

and the weight of the dry products of combustion per pound of dry coal becomes

$$0.8051 \times 19.359 = 15.586\ lb.$$

*From Mr. Pratt's new book, "Principles of Combustion in the Steam Boiler Furnace," by permission of the Babcock & Wilcox Co.

which checks with the value of Table I within 0.03 per cent.

The total weight of gas per pound of coal fired will be the sum of the dry products per pound of dry coal, the water vapor from the hydrogen and the weight of moisture per pound of coal, or

$$15.591 + 0.452 + 0.029 = 16.072\ lb.$$

The weight of dry air supplied per pound of carbon, from formula (28) will be

$$\frac{3.036 \times 80.863}{13.057} = 18.802\ lb.$$

The weight of dry air supplied per pound of coal, using the actual carbon weight, will be

$$18.802 \times 0.7986 = 15.015\ lb.$$

while the weight using the carbon weight corrected for the sulphur equivalent (in this case the ratio of the nitrogen in the air supplied for the combustion of carbon and sulphur to CO_2 and SO_2 respectively) will be

$$18.802 \times [0.7986 + (0.012 \div 2.667)] = 15.100\ lb.$$

The actual weight of air supplied per pound of dry fuel will be the total products of combustion per pound of dry coal less the weight per pound which is burned and appears in such products, or, from Table I and the weight of ash as given by the analysis:

$$16.043 - (1 - 0.078) = 15.121\ lb.$$

For this particular coal then, the foregoing errors, using the uncorrected and the corrected values of carbon as applied to formula (28), are 0.070 per cent. and 0.14 per cent. respectively.

Formulas (28), (28a) and (28b) will, as stated, give results within reasonably accurate limits, with fuels having a low nitrogen content, the error varying with the percentage of nitrogen and with the amount of air used for combustion. With fuels of high nitrogen content, the error may be as great as 80 to 90 per cent. (see blast-furnace gas), and for such fuels these formulas are not to be relied upon.

The heat of combustion per pound of dry coal computed from formula (4) will be

$$14600 \times 0.7986 + 62000\ (0.1502 \frac{0.0427}{8}) + 4050 \times 0.0118 = 14{,}492\ B.t.u.$$

as against the calorimetrically determined value, 14,351 B.t.u., an error of 0.99 per cent.

To indicate the amount of possible error with high-sulphur fuels, in the determination of the dry products of combustion per pound of fuel from formula (27) where the carbon content is not corrected for the sulphur equivalent, let us assume a coal having the analysis given below. The weight of oxygen and air theoretically required, and the weight of the products of perfect combustion per pound of dry coal will be as in Table VI.

TABLE VI. WEIGHT OF OXYGEN AND AIR REQUIRED FOR COAL—PRODUCTS OF PERFECT COMBUSTION

	Weight per Pound Coal, Pounds	Required—Pounds		Products of Combustion—Pounds per Pound Coal				
		O_2	Air	CO_2	O_2	N_2	H_2O	SO_2
C	0.6125	1.6335	7.0560	2.2460	.....	5.4225	.....	.....
H_2	0.0448	0.3584	1.5483	.....	.....	1.1698	0.4032	.....
O_2	0.1062	.....	.....	.....	0.1062	.....	.....	.....
N_2	0.0100	.....	.....	.....	.....	0.0100	.....	.....
S	0.0442	0.0442	0.1909	.....	.....	0.1467	.....	0.0884
Ash	0.1823	.....	.....	.....	.....	.....	.....	.....
		2.0361	8.7952	2.2460	0.1062	6.7690	0.4032	0.0884
O_2 in coal....		0.1062	0.4588	.....	0.1062	0.3526	.....	.....
		1.9299	8.3364	2.2460	0.0000	6.4164	0.4032	0.0884
SO_2 as CO_2...		.....	.....	0.0884	.....	.....	.....	0.0884
		1.9299	8.3364	2.3344	0.0000	6.4164	0.4032	0.0000

The air required per pound of dry coal for perfect combustion is thus 8.3364 lb. If we assume the coal to be burned with 20 per cent. excess air, there will appear in the products of combustion, in addition to the weights just given, $1.6673 \times 0.2315 = 0.3860$ lb. O_2 and $1.6673 \times 0.7685 = 1.2813$ lb. N_2. With 20 per cent. excess air, then, the weight of the products of combustion per pound of dry coal, these weights expressed in terms of percentage weight, expressed in terms of percentage weight of dry products, and expressed in terms of percentage volume of dry products, are as follows:

	Weight Products, Pounds	Per Cent. Weight Products	Per Cent. Weight Dry Products	Per Cent. Volume Dry Products
CO_2	2.3344	21.572	22.407	15.603
O_2	0.3860	3.567	3.705	3.547
N_2	7.6977	71.135	73.888	80.850
H_2O	0.4032	3.726	.....	.....
	10.8213	100.000	100.000	100.000

Under the assumed conditions, the weight of dry gas per pound of carbon will be from formula (27):

$$\frac{11 \times 15.603 + 8 \times 3.547 + 7 \times 80.850}{3 \times 15.603} = 16.3635\ lb.$$

Multiplying the value by 0.6125, the weight of carbon per pound of dry coal, we have as the dry products per pound

$$16.3635 \times 0.6125 = 10.022\ lb.$$

as against the computed value above,

$$10.8213 - 0.4032 = 10.418\ lb.,$$

an error of approximately 4 per cent. If, on the other hand, the weight of carbon is corrected for the sulphur equivalent, we have

$$16.3635 \times (0.6125 + (0.0442 \div 1.833)) = 10.417\ lb.,$$

which value checks with the computed weight.

Calculations for Fuel Oil

Given an oil having an ultimate analysis as follows: Carbon, 84 per cent.; hydrogen, 12.7 per cent.; oxygen, 1.2 per cent.; sulphur, 0.4 per cent.; nitrogen, 1.7 per cent.

With perfect combustion the oxygen and air required per pound of oil, and the products of combustion per pound will be as in Table VII.

TABLE VII. AIR REQUIRED FOR COMBUSTION OF OIL—PRODUCTS OF COMBUSTION

	Weight per Pound Oil, Pounds	Required—Pounds		Products of Combustion—Pounds per Pound of Oil				
		O_2	Air	CO_2	O_2	N_2	H_2O	SO_2
C	0.8400	2.240	9.677	3.080	...	7.437	.....	.....
H_2	0.1270	1.016	4.389	.....	.....	3.373	1.143	.....
O_2	0.0120	.....	.....	.....	0.012	.....	.....	.....
S	0.0040	0.004	0.017	.....	.....	0.013	.....	0.008
N_2	0.0170	.....	.....	.....	.....	0.017	.....	.....
		3.260	14.083	3.080	0.012	10.840	1.143	0.008
O_2 in oil.....		0.012	0.052*	.....	0.012	0.040*	.....	.....
		3.248	14.031	3.080	0.000	10.800	1.143	0.008
SO_2 as CO_2...		.....	.....	0.008	.....	.....	.....	0.008
		3.248	14.031	3.088	0.000	10.800	1.143	0.000

*Air and N_2 equivalents of O_2 in oil.

The weight of air theoretically required for the combustion of one pound of oil is, then, 14.031 lb. For each 20 per cent. supplied in excess of this weight of air (each 2.8062 lb. above 14.031), there will appear in the products of combustion $2.8062 \times 0.2315 = 0.6996$ lb. O_2 and $2.8062 \times 0.7685 = 2.1566$ lb. of N_2, and for varying amounts of excess air the weights of the products of combustion per pound of oil will be as given in Table VIII.

TABLE VIII. WEIGHT OF PRODUCTS COMBUSTION OF OIL WITH VARYING EXCESS AIR

	Weight Products Perfect Combustion	Weight Products—Varying Amounts Excess Air—Pounds				
		20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent
CO_2	3.088	3.088	3.088	3.088	3.088	3.088
O_2	0.000	0.650	1.299	1.949	2.598	3.248
N_2	10.800	12.957	15.113	17.270	19.426	21.583
H_2O	1.143	1.143	1.143	1.143	1.143	1.143
	15.031	17.838	20.643	23.450	26.255	29.062

Expressed in terms of percentage weight, these values are as given in Table IX.

TABLE IX. PERCENTAGE WEIGHT OF PRODUCTS OF COMBUSTION OF OIL

	Per Cent. Weight Products Perfect Combustion	Per Cent. Weight Products—Varying Amounts Excess Air				
		20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent.
CO_2	20.544	17.311	14.959	13.169	11.762	10.626
O_2	0.000	3.644	6.293	8.311	9.895	11.176
N_2	71.852	72.637	73.211	73.646	73.990	74.265
H_2O	7.604	6.408	5.537	4.874	4.353	3.933
	100.000	100.000	100.000	100.000	100.000	100.000

Expressed in terms of percentage weight of dry products of combustion these values are as given in Table X.

TABLE X. PERCENTAGE WEIGHT DRY PRODUCTS OF COMBUSTION OF OIL

	Per Cent. Weight Dry Products Perfect Combustion	Per Cent. Weight Dry Products—Varying Excess Air 20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent.
CO_2	22.235	18.496	15.836	13.844	12.297	11.061
O_2	0.000	3.894	6.662	8.737	10.345	11.634
N_2	77.765	77.610	77.502	77.419	77.358	77.305
	100.000	100.000	100.000	100.000	100.000	100.000

Converting these percentages by weight of the dry products of combustion into terms of percentage by volume, the values of Table X become as in Table XI.

TABLE XI. PER CENT. VOLUME DRY PRODUCTS OF COMBUSTION OF OIL

	Per Cent. Volume Dry Products Perfect Combustion	Per Cent. Volume Dry Products—Varying Excess Air 20 Per Cent.	40 Per Cent.	60 Per Cent.	80 Per Cent.	100 Per Cent.
CO_2	15.395	12.686	10.788	9.384	8.304	7.446
O_2	0.000	3.672	6.240	8.144	9.605	10.769
N_2	84.605	83.642	82.972	82.472	82.091	81.785
	100.000	100.000	100.000	100.000	100.000	100.000

Assume, for the purpose of comparing the data thus computed with the results obtained from the use of the combustion formulas, that the oil is burned with 20 per cent. excess air and that the flue-gas analysis shows 12.686 per cent. CO_2, 3.672 per cent. O_2 and 82.972 per cent. N_2.

The weight of dry products of combustion per pound of carbon is, from formula 27,

$$\frac{11 \times 12.686 + 8 \times 3.672 + 7 \times 83.642}{3 \times 12.686} = 19.823 \text{ lb.}$$

Multiplying this value by the weight of carbon per pound of oil, we have as the weight of dry gas per pound of oil,

$$19.823 \times 0.84 = 16.651 \text{ lb.}$$

as against the value from Table VIII,

$$17.838 - 1.143 = 16.695 \text{ lb.}$$

If the carbon weight is corrected for the sulphur equivalent, the two volumes may be made to check exactly, and we have as the weight of dry gas per pound of oil

$$19.823 \times [0.84 + (0.004 \div 1.833)] = 16.695 \text{ lb.}$$

The total gas weight per pound of oil will be the dry gas weight plus the weight of moisture resulting from the burning of 0.127 lb. of hydrogen, or

$$16.695 + (0.127 \times 9) = 17.838 \text{ lb.},$$

and since all the fuel will appear in the products of combustion, the weight of air supplied per pound of oil will be

$$17.838 - 1 = 16.838 \text{ lb.}$$

This value checks with the computed value of the theoretical requirement plus 20 per cent. excess, or

$$14.041 + (0.20 \times 14.041) = 16.837 \text{ lb.}$$

The weight of air supplied per pound of carbon from formula (28) is

$$(3.036 \times 83.64) \div 12.686 = 20.017 \text{ lb.}$$

and the weight per pound of oil, using the corrected carbon weight,

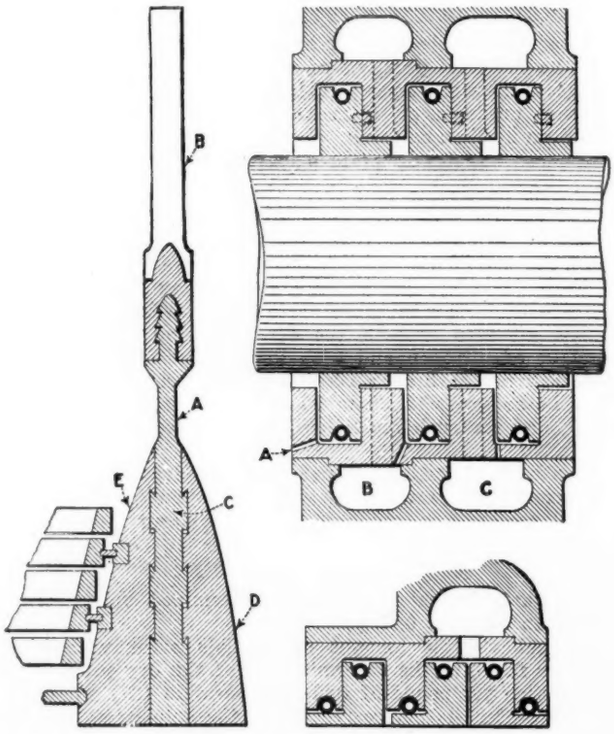
$$20.017 \times (0.84 + (0.004 \div 2.667)) = 16.843 \text{ lb.},$$

the slight difference between this value and the actual weight being due to the nitrogen content of the oil.

New Turbine Disk and Carbon Packing Rings

Two interesting English patents relative to steam-turbine parts have been recently announced by London *Engineering*. One relates to a turbine disk for large machines and is of special interest to builders and users of turbines; this patent is by the Brush Electrical Engineering Co., London.

In the manufacture of large turbine disks for high-speed steam or gas turbines, difficulties arise in hardening the disks in order to obtain the same strength in the inner and outer parts thereof. It has therefore been proposed to build up turbine disks of a number of separate interconnected elements to relieve the strains and tensions due to rapid rotation, and the present invention relates to a turbine disk of this kind in which three members—a complete intermediate disk and two complete side disks—are connected together by means of a number of grooves having a dovetailed form, provided in the surface of the disks, and fitting one another when the side disks are shrunk on to the intermediate disk. In such an arrangement the side disks and the intermediate disks will act conjointly to resist the stresses caused by rotation. In manufacturing large turbine disks this arrangement also allows of obtaining such dimensions as may be suitable for forging and hardening. The illustration shows a longitudinal section through a turbine disk. On the intermediate member *A* of the turbine disk the radial blades *B* are arranged. By means of the dovetailed grooves *C* the outer members or the side disks *D* and *E* have been shrunk onto the intermediate disk *A*, thus forming, together with the latter,



LEFT—LAMINATED TURBINE WHEEL. RIGHT—NEW FORM OF GLAND PACKING FOR TURBINES

a rigid construction, so that tensions caused in the intermediate disk *A*, owing to rotation, will be transmitted to the side disks *D* and *E* and resisted thereby.

The patent on the carbon gland rings is by the Hon. Sir C. A. Parsons, S. S. Cook and L. M. Douglas, Heaton Works, Newcastle-on-Tyne.

Carbon glands for packing steam-turbine spindles as heretofore designed consist of rings, each ring being made up of sectors of graphitic carbon or similar material, usually of rectangular cross-section, embracing the rotating shaft and held together by a spring encircling them, the purpose of such carbon gland ring being to baffle the flow of steam from a higher pressure on one side of it to a lower pressure on the other. The outer periphery of the gland ring is in such case subjected over its whole area to the higher pressure, while its inner periphery, which is in contact with or is bored to fit the surface of the shaft, is subject to a lower average pressure, owing to the fall of pressure from the high-pressure side to the low-pressure side. It follows, therefore, that there is a radial inward force on the ring pressing it toward the shaft, thus giving rise to friction-absorbing power and producing a corresponding amount of heat. In the new form of gland ring the cross-section is more or less L-shaped, and the outer circumference of the foot of the L is subjected to a lower steam pressure than that on the greatest diameter

of the ring. Thus the sum of the pressures on these two faces can be made to approximate to that on the inner face, and the ring be put in equilibrium. In the drawing the high-pressure side of the packing is on the left. High-pressure steam finds its way through the opening *A* and bears on the outside of the first ring. Lower pressure steam is provided to the space *B* and acts on the smaller diameter of the first ring, besides the larger diameter of the second ring. The same arrangement is carried out with the second space *C* and the final low-pressure is admitted direct to the foot of the L in the case of the last ring. Several variations of the idea are mentioned in the specification.

N. A. S. E. Convention at Huntington, W. Va.

At the present writing there is every indication that the thirty-seventh annual convention of the National Association of Stationary Engineers to be held in Huntington, W. Va., during the week of Sept. 8, will be up to the usual standard of the organization. Headquarters will be at the Frederick Hotel, and the mechanical exposition will be held in the Chamber of Commerce Building. Continuing the policy inaugurated two years ago, more time will be given to technical papers and welfare discussions and less to routine business, by limiting committee and official reports to brief summaries. Five papers and two welfare discussions are on the program.

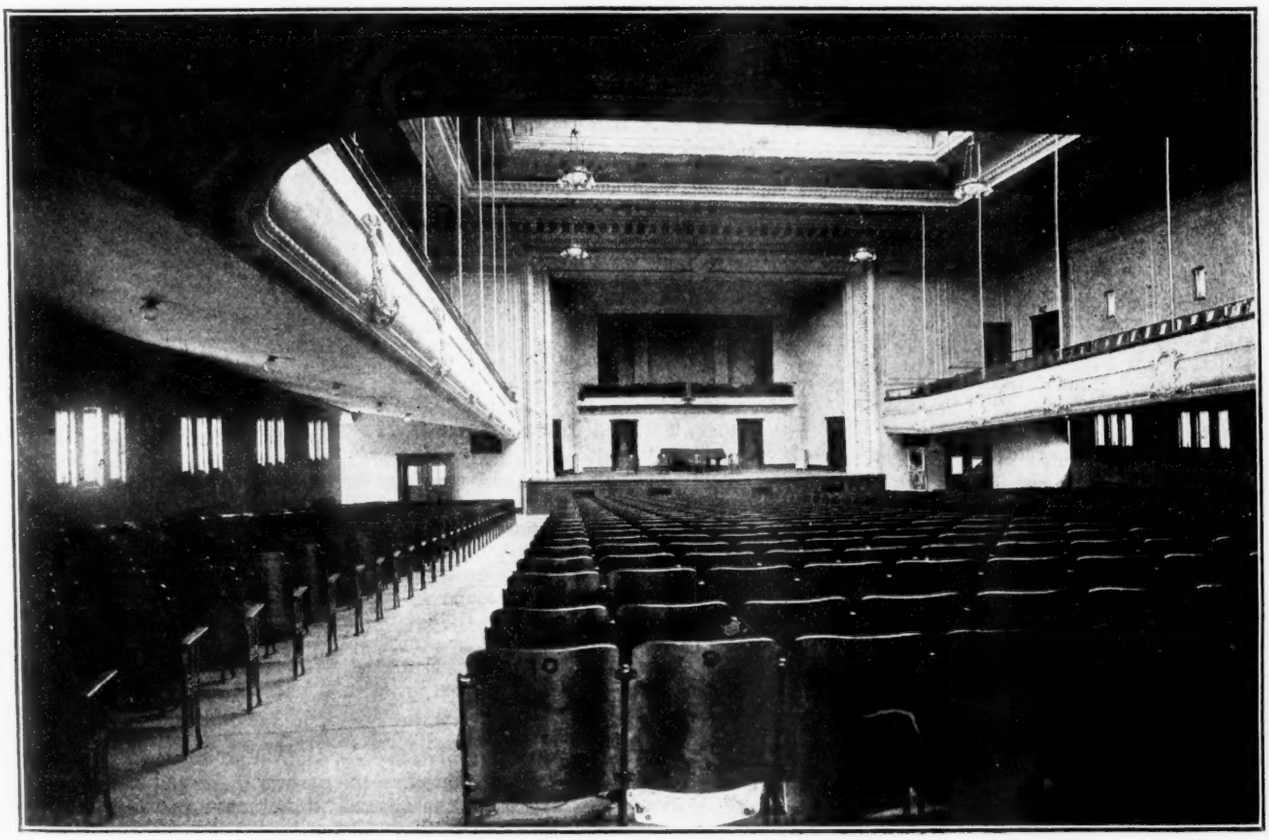
That Huntington and the surrounding territory is a new field for the convention has interested the manufacturer of power-plant products. The numerous coal mines of the state are also taking notice, and the predictions are that the exhibits will be more numerous and better than they have been for several years. The Chamber of Commerce is taking an active interest and is assisting materially the local convention committee, composed of the following seven members: C. L. Humphries, chairman; James Fields, secretary; R. C. Flaugher, R. D. Wylie, A. R. Hetzer, C. Speer and W P. Yates. The convention program follows:

Monday, Sept. 8, official registration of delegates and visitors at headquarters, the Frederick Hotel, from 9 a.m. to 9 p.m. During the day the local reception committee will meet all trains and escort delegates and visitors to headquarters. At 8 p.m. the mechanical exposition in the Chamber of Commerce Building will be formally opened. There will be addresses by Charles Cullen, president of the National Exhibitors' Association, and Roderick Mackay, national president of the association. At 10 p.m. an informal reception of national officers will be held at the Frederick Hotel. Delegates, visitors and committeemen are expected to be present.

Tuesday, Sept. 9, at 9 a.m., officers, delegates and visitors will assemble at headquarters and parade to the Municipal Building, where the opening exercises of the convention will be held, beginning at 10 o'clock. Addresses will be made by Governor John J. Cornwell, National President Roderick Mackay, Mayor C. W. Campbell, National Vice President John J. Calahan, a representative of the Chamber of Commerce, Past National President John A. Wickert, Charles Cullen, president of the National Exhibitors' Association, and a representative of the local manufacturers' association. At the end of the opening exercises National President Mackay will announce the convention committees. The official convention photograph will be taken at noon. At 1:30 p.m. the first business session of the convention will be devoted to reports of the national officers and standing committees presented in abstract; at 3 p.m. a lecture on "National Water Power Conservation," by Thomas J. Royer, of Los Angeles, Calif.; at 4:30 p.m. the annual meeting of the Life and Accident Department will be held.

Wednesday, Sept. 10, 9 a.m., convention session for presentation of additional committee reports and routine business; 10:30 a.m., a lecture on "Bonuses in the Power Plant," by Walter N. Polakov, of New York City; 11:30 a.m., welfare discussion on "Shortening the Distance from Engine Room to Office," a general discussion for the delegates. The afternoon session will be devoted to an outing and field sports.

Thursday, Sept. 11, 9 a.m., convention session, reports



INTERIOR VIEW OF MUNICIPAL AUDITORIUM, HUNTINGTON, W. VA.

of convention committees and legislative actions on recommendations; 10:30 a.m., lecture on "Power Plant Records," by John B. McGowan, of Brooklyn, New York; 1:30 p.m., session of convention, consideration of committee reports and legislation thereon; 3 p.m., lecture on "The Consulting Engineer in the Power Plant," by Charles A. Cahill, of Milwaukee, Wis.; 4:15 p.m., welfare discussion on "Attention to Details of Operating Routine in Power Plants," a general discussion for delegates; 8 p.m., entertainment by the National Exhibitors' Association in the exhibition hall.

Friday, Sept. 12, 9 a.m., lecture on "James Watt and His Achievements," by Royal H. Holbrook, of Cedar Rapids, Iowa; 9:45 a.m., business session of the convention, legislative action on unfinished business, selection of 1920 convention city and election of officers; 8 p.m., public installation of officers and grand ball at Frederick Hotel.

Comparative Coal Production and Shipments

A report has been issued by the Geological Survey of the Department of the Interior in which the present production and shipments of coal and coke are compared with those of the corresponding period of 1918. It is shown that not only are the fields of Pennsylvania producing at a rate far below that of last year, but the same condition exists in practically every other producing district in the country.

The production of bituminous coal in the week ended July 12 is estimated at 10,169,000 net tons, an average per day of 1,695,000 tons, compared with an average of 1,492,000 tons for the five working days in the previous week, and compared with 2,214,000 tons in the week ended July 13, 1918. The production for the calendar year to date was 230,522,000 tons, or approximately 77,600,000 tons less than in the corresponding period last year. The average daily production, considering only working days, has been about 500,000 tons less this year than last year.

The estimated production of anthracite in the week ended July 12 was 1,874,000 net tons, compared with 2,136,000 tons in the corresponding week last year, and the average daily production in the week ended July 12 was 312,000 tons, compared with 282,000 tons in the previous week, and 356,000 tons in the corresponding week last year. The production of anthracite to date is estimated at 42,078,000 tons, or 10,780,000 tons less than in the corresponding period last year.

Returns from the operators for the week ended July 5 record an improvement in market conditions, the loss of time on account of no market averaging 24.3 per cent. of full time in the week, compared with 27.5 per cent. in the week ended June 28, and more than 32 per cent. in the first half of June. Market conditions in Illinois and Indiana were better, and the Hazard, Kentucky and Westmoreland, Pennsylvania, districts recorded notable improvements. Less than 4 per cent. of the full-time operation was lost because of no market in western Pennsylvania, less than 1 per cent. in the Westmoreland and neighboring fields, and central Pennsylvania showed an improvement. Car supply was better in the week ended July 5 than in the previous week in all districts except Illinois, Indiana, southern Ohio and central Pennsylvania, while losses due to shortage of labor increased in every district save southern Ohio and Alabama.

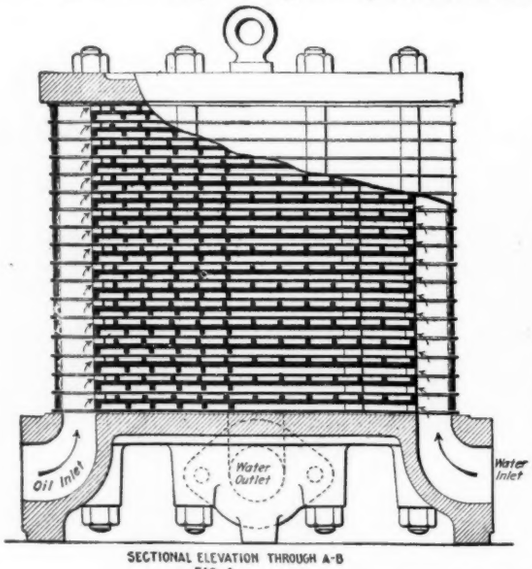
The production of beehive coke in the week ended July 12 is estimated at 325,648 net tons, compared with 680,000 tons in the week ended July 13, 1918, and with 264,328 tons in the 5-day week of July 5, 1919. The production of beehive coke to date is estimated at 10,197,481 net tons, as against 16,412,818 tons in the corresponding period of last year.

Bituminous coal dumped at lower Lake Erie ports in the week ended July 5 was 923,939 net tons, compared with 994,901 tons in the week ended June 28, and 861,093 tons in the first week of July, 1918. The total lake coal dumped from Jan. 1 to July 5, 1919, was 10,053,441 tons, compared with 8,560,516 tons in the corresponding period, last year.

The Dex Oil Cooler

In view of the developments that are taking place and the continued increase in the size of prime movers, the problem of efficiently cooling the large quantities of oil required for the bearings of turbines, thrust bearings and gear boxes—like many of the details in a large power installation—plays an important part in the smooth running of the station, and has compelled designers and those responsible for the running and maintenance of such installations to investigate the subject in some detail.

We have received particulars of the "Dex" oil cooler (Harrison's patent), which is being manufactured by W. H. De Ritter & Co., Ltd., of Limehouse, London, E. This cooler is of a new type and, being compact and very accessible for cleaning, has advantages over many of the older patterns of tubular coolers. Its leading features are shown in Figs. 1 and 2; they consist in the use of flat plates cast with ribs (see Fig. 3) on both sides, assembled alternatively with plain rolled plates, the nest of plates being held together by bolts connecting heavy cast-iron headers on which



SECTIONAL ELEVATION THROUGH A-B
FIG. 1

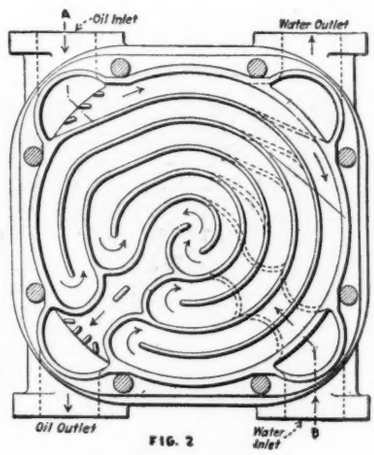


FIG. 2

FIGS. 1 AND 2. TWO VIEWS OF THE DEX OIL COOLER

are arranged the inlet and outlet connections for the oil and the cooling water. The ribbed plates are die-cast and then ground on both faces. This work must be carefully carried out to insure that when they are assembled with the plain plates the joints are sound. This is essential, not only to avoid short paths for the fluids, but to prevent leakage from the oil passage to the water passage, or vice versa. When it is desirable to clean or examine the plates, it is only necessary to withdraw the bolts, when each plate can be readily removed and brushed over.

The oil and water are circulated through the rectangular passages and in reverse direction in the alternate layers and after circulation are delivered to their respective pockets, as indicated by the arrows in Figs. 1 and 2.

In Fig. 2 all the oil and water passages are in parallel, but it will be readily seen that by the introduction of baffles in the pockets the parallel system of working may be

changed to the series system with two, three or more flows, thus increasing the path to be traversed by the oil to be cooled.

The shallow rectangular passages for the fluids give a high heat-transmission efficiency without undue friction, and from tests carried out by the manufacturers it was found that a transmission factor of 270 B.t.u. per 1 deg. F. per square foot was obtained for a drop of 15 lb. pressure between the inlet and outlet connections. It appeared, moreover, that this transmission factor varied in direct proportion to the velocity of the oil and that the velocity was nearly proportional to the pressure.

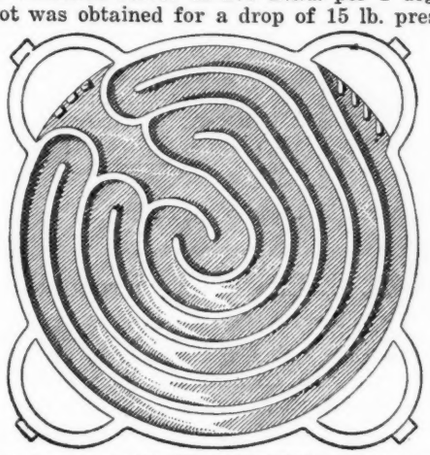


FIG. 3. FLAT PLATE, SHOWING CAST RIBS

The makers of this cooler are prepared to supply them for the services already mentioned, and also for cases where it is required to transmit heat between two substances one of which is a gas or vapor.—London *Engineering*.

Frederick Sargent

Frederick Sargent, senior member of the firm of Sargent & Lundy, of Chicago, and one of the most prominent consulting engineers in the United States specializing in the design of electric generating stations, died at his home, in Glencoe, Ill., July 26, having been taken ill while abroad. An Englishman by birth, Mr. Sargent had made numerous trips to his native country, the last of which was made in April and May of this year in company with his close friend, Samuel Insull.

Frederick Sargent was born in Liskeard, Cornwall, England, on Nov. 11, 1859, which is also the exact date of the birth of Samuel Insull, another Englishman and Chicagoan, with whom Mr. Sargent was destined to be intimately associated during practically all of his engineering activities. His people were of the farming class, but young Sargent developed a decided mechanical bent, and eight years of his boyhood and youth were spent in acquiring practical mechanical knowledge and experience in the works of John Elder & Co., the great shipbuilders on the River Clyde, near Glasgow. During this time he gained an extensive and practical knowledge of mechanical engineering, paying particular attention to heavy machinery. He also improved his education by going to night school at Glasgow University. Coming to the United States about 1880, he found employment in Eastern shipbuilding yards as a designer of steam engines. He then went West as a designer for the Sioux City (Iowa) Engine Co. A year or so later he accepted a position with E. P. Allis & Co., of Milwaukee, predecessors of the present Allis-Chalmers Manufacturing Co. Here he attracted the attention of the officers of the Western Edison Light Co., organized in Chicago in 1882 to exploit the electric-lighting inventions of Thomas A. Edison in the West, and in the fall of 1884 he moved to Chicago and began his career as an electrical engineer in that city.

Succeeding the Western Edison Light Co., the Chicago Edison Co. was formed in 1887. This was the first distinctively Edison central-station company in Chicago. Mr Sargent became its consulting engineer, and he has been consulting engineer of that company and its successor, the present Commonwealth Edison Co., ever since.

About 1889 he went to New York under contract with the Edison United Manufacturing Co. In this position he had general charge of all the work done by that company in the United States and Canada. Shortly after this the company in New York was reorganized as the Edison General Electric Co. Mr. Sargent was made assistant chief engineer of the new corporation, of which Samuel Insull was vice president in charge of manufacturing. But Mr. Sargent had determined to open an office of his own, and, in August, 1890, he returned to Chicago and established himself as an independent electrical and mechanical engineer. The firm of Sargent & Lundy was formed in 1891.

In 1891 and 1892 Mr. Sargent was consulting electrical engineer for the World's Columbian Exposition, and he designed the power plant and had much to do with the other mechanical and electrical features of the great World's Fair of 1893.

The original Edison central station in Chicago was built about 1889. Mr. Sargent made the plans for the machinery layout of that station. In 1892 Samuel Insull came to Chicago as president of the Chicago Edison Co., and that company at once took on a new lease of life. Under Mr. Insull's direction the old Harrison Street station, recently torn down to make way for the Union Station railroad improvements, was built. Mr. Sargent was the designer of that station, also the Fisk Street Station, the Quarry Street Station and the Northwest generating stations of the Commonwealth Edison Company.

FREDERICK SARGENT

He was one of the first mechanical engineers who recognized the great part that the steam turbine was destined to play in the development of electric generating stations. The Fisk Street Station was the pioneer of all the large turbine central stations of the world, and it became deservedly famous for its many original features of design

and for the simplicity and economy of operation. After this station had been in operation for a short time, Mr. Sargent was sent to London as a representative of the United States on the hearing in Parliament in connection with the London power-supply bill. This hearing crystalized in Mr. Sargent's mind some ideas he had been developing about the importance of unified power supply for great industrial centers so as to reduce the cost of production, and on his return he submitted his ideas to Mr. Insull, and they were marked out in the power station development of the Commonwealth Edison Company.

Mr. Sargent's engineering work was not confined to Chicago. He was consulting engineer for many of the important electric-light and power companies throughout the country, including the Edison Electric Illuminating Co., Boston; American Gas and Electric Co., New York; Electric Bond and Share Co., New York; the Union Gas and Electric Co., Cincinnati, and many other smaller organizations.

He designed the great combined central power station of the American Gas and Electric Co. and the West Penn Power Co., located on the Ohio River, north of Wheeling, W. Va., which is the first large electric station to be built in a favorable locality on a coal mine for the distribution of power to industrial centers at long distances.

He designed the great new station of the Union Gas and Electric Co., at Cincinnati, which was recently completed. He also designed the new station for the Kansas City Light and Power Co., which is soon to be put into operation. He went to Chile in 1916 as consulting engineer for the Guggenheim mining interests on the development of a power supply for their mine at Chuquicamata.

During the war Mr. Sargent was consulting engineer for the power station of the Edgewood Arsenal, at Edgewood, Md., and also consulting engineer for the United States Government in other wartime projects demanding the application of power on a large scale.

In his profession Mr. Sargent was noteworthy for the clear vision and strong common sense with which he grappled with the essentials of an engineering problem. He was simple, clear, direct and practical. He was a man of broad outlook, tolerant, modest, seeking to achieve results rather than to uphold theories. And he was eminently successful in obtaining results, for his electrical generating stations were milestones of achievement in the economical production of electrical energy.

Mr. Sargent was awarded a medal by the World's Columbian Exposition in 1893. He was a member of the jury of awards in power engineering at the St. Louis Exposition of 1904. He was a member of several societies and clubs, including the American Society of Mechanical Engineers, Western Society of Engineers, University Club, Chicago Yacht Club, Skokie Country Club and the Engineers Club, New York.

He is survived by a widow, one daughter and two sons.

New N. A. S. E. in New Brunswick, N. J.

State Deputy John J. Reddy of New Jersey continues to institute new subordinate associations in his state. Tuesday evening, July 29, he instituted an association at New Brunswick, about twenty engineers joining. Wurt Illig was elected president. Among those present were: National Vice President John J. Calahan, William Reynolds, chairman of the board of trustees; Howard Cole, of New York; James S. Heath, past president of the New Jersey State Association, and Charles H. Bromley, of the State Educational committee.

During the two years Mr. Reddy has been deputy, he has instituted associations at Phillipsburg, Dover, Cape May, New Brunswick and Camden, the last having been instituted Aug. 1. Such excellent results are due to the combined efforts of Mr. Reddy and the visiting committee centered around the unusually hard work of the educational committee.

Personals

E. O. Floyd has been appointed general sales manager of the Rosendale-Reddaway Belting and Hose Co., Newark, N. J.

N. S., Thulin has been appointed special railroad representative on the staff of S. C. Sprague, manager of Western railroad sales for the Chicago Pneumatic Tool Co.

Herman G. Hardy, formerly connected with the Old Hickory Powder Plant at Jacksonville, Tenn., is now chief mechanical and electrical engineer of the Arizona Copper Co., Ltd., Clifton, Ariz.

Capt. H. P. Childs, of the 23rd Engineers, recently returned from France, is now representing the Frederick Iron and Steel Co., of Frederick, Md., manufacturers of centrifugal pumps and other engineering products, at 61 Broadway, New York City. Prior to his military service Mr. Childs was assistant to the first vice president and general manager of the Westinghouse Machine Co. in New York.

George H. Diman, formerly with the American Woolen Co.'s mills, Lawrence, Mass., has retired from active duty with this company after 32 years of continuous service. He is still retained as a member of the company's general advisory board. Of his 74 years, 53 have been spent as a power-plant engineer in the textile mills of New England. He has specialized as a fuel economist and in the economical use of steam for power production and manufacturing purposes. His arrangement with the American Woolen Co. does not preclude his consultation by others, and he is available for such service, consulting and otherwise, as his long and extended experience has fitted him to render.

Miscellaneous News

The Alberta Industrial Development Association will hold an Industrial Congress and Provincial Tour, Aug. 11-17. The congress will be held at Calgary, Aug. 13-14, and the tour, by special train, begins at Medicine Hat on Aug. 11, concluding at Banff in the Canadian Rockies, on Aug. 17. The congress will place before its visitors data in relation to the natural resources and industries of Alberta and the Canadian West with the object that more serious consideration be given to the economic development of trade relations between the United States and Canada. Many men of international reputation will address the convention.

Business Items

J. C. Bennett, of Detroit, is now manufacturing Planet soot blowers for all types of boilers at Windsor, Ont., Can., under the name of J. C. Bennett & Co. The Equipment Specialties Co., Ltd., of Montreal and Toronto, have been given the exclusive sales rights, as has also the Marion Machine and Foundry Supply Co., of Marion, Ind.

The Sullivan Machinery Co., Chicago, Ill., announces the following changes in its personnel: Marion C. Mitchell has been appointed sales manager for the territory in Indiana and Illinois, previously controlled from the St. Louis office, with temporary headquarters in the Railway Exchange, St. Louis; Don M. Sutor, formerly manager of the El Paso office, has been appointed sales manager for the territory of western Kentucky, western Tennessee, Missouri, Arkansas, Oklahoma and Kansas (except the oil territory), with headquarters at Railway Exchange, St. Louis; Daniel H. Hunter has been appointed sales manager for Louisiana, Texas (except the southwestern section), and the oil fields of Oklahoma and Kansas, with headquarters in Dallas, Tex.

Trade Catalogs

Jos. H. Roach & Co., Inc., Philadelphia, Penn., has issued a 15-page catalog fully illustrating and describing "The Roach Stoker."

Hornung Pressure and Temperature Control, J. C. Hornung, Chicago, Ill. Bulletin No. 14. Pages 12; 6 x 9 in.; fully illustrated.

United Stokers Corp., Chicago, Ill., has issued an 8-page Bulletin No. 100, illustrating and describing the "Simplex Steam Jet Ash Conveyor." A copy of this bulletin may be had free upon request.

The Spray Engineering Co., Boston, Mass., has issued a 16-page bulletin illustrating and describing the "Spraco Air Washing and Cooling Equipment," which is especially applicable to Steam Turbine Generators.

The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penn., has just issued its 23-page Application Circular 7375, on "Electrical Precipitation," describing the recovery of valuable material from smoke and gases; fully illustrated.

The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has issued a 17-page bulletin No. 1538 on "Forgings." Illustrations showing some of the company's forge and machine-shop equipment used in the production of forgings are given.

The Black & Decker Manufacturing Co., Baltimore, Md., has recently issued a catalog giving a full and illustrated description of electric air compressors, portable electric drills, and electric valve grinders. A copy of this catalog may be had free upon request.

The Vulcan Soot Cleaner Co., Du Bois, Penn., has issued bulletin No. 541, which illustrates in two colors and describes the Vulcan patented diagonal method for cleaning soot from the tubes of horizontal water-tube boilers. A copy of the bulletin may be had free upon request.

The Wellman-Seaver-Morgan Co., Cleveland, Ohio, has issued Bulletin No. 22, containing three full-page charts giving the relations in any shaft between power, shaft diameter, torsional stress and speed, with examples showing methods of use of charts. This useful bulletin for engineers and draftsmen may be had free upon request.

The Texas Co., New York City, has just published a 46-page book, 9¼ x 12¾ in., entitled "Texaco at Home and Abroad." The book is very nicely printed and prettily illustrated with pen and pencil sketches of interesting items and short stories about the business, which reveal more than a little of the interest and even of the romance that permeates the operation of so large and successful a business as the marketing of Texaco petroleum products throughout the world.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.35@2.80	$2.80@3.60
Philadelphia, gross tons	4.49@5.00	5.00@5.80
New York, gross tons	4.85@5.35	5.35@6.15
Alongside Boston (water coal), gross tons	6.35@7.05	6.85@7.65

Pocahontas and New River are quoted at $6.00 @6.25 per gross ton f.o.b. Norfolk and Newport News, Va., in response to export demand. There are practically no spot sales for coastwise shipments.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Tidewater		Mine	Tidewater
Broken	$5.95	$7.80	Pea	5.20	6.95
Egg	6.25	8.10	Buckwheat	3.40	5.15
Stove	6.50	8.35	Rice	2.75	4.50
Chestnut	6.60	8.45	Barley	2.25	4.00

Bituminous

	Spot
South Fork (Best)	$2.95@3.25
Cambria (Best)	2.95@3.10
Cambria (Ordinary)	2.45@2.60
Clearfield (Best)	2.95@3.10
Clearfield (Ordinary)	2.45@2.60
Reynoldsville	2.50@2.75
Quemahoning	2.85@3.00
Somerset (Best)	2.85@3.00
Somerset (Poor)	2.35@2.60
Western Maryland	2.35@2.60
Fairmont	1.90@2.25
Latrobe	2.20@2.35
Greensburg	2.35@2.50
Westmoreland ¾ in.	2.75@2.90
Westmoreland run-of-mine	2.50@2.60

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Anthracite Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6.05	7.90	Rice	2.75	3.65
Stove	6.30	8.15	Boiler	2.50	3.50
Nut	6.40	8.25	Barley	2.25	3.15
Pea	5.00	6.60	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.40@1.60	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.95@$4.60
Corona	3.50
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2.00@2.25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	.....
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; other rates 92½c.

Engr.

New Construction

PROPOSED WORK

Mass., Worcester—The Worcester Paper Box Co., 68 High St., will soon receive bids for the construction of a 2 story, 60 x 150 ft. garage on Austin St. and Houchin Ave. A steam heating system will be installed in same. Total estimated cost, $45,000. S. H. Pitcher Co., 44 Front St., Engr.

Conn., Stamford—The Board of Education plans to construct a grammar school on State and South St. A steam heating system will be installed in same. Total estimated cost, $225,000. Emmens & Abbott, Washington Bldg., Engr.

N. Y., Brooklyn—Coyne & Delaney, 832 Kent Ave., will install a steam heating system in the 3 story, 50 x 120 ft. factory which it plans to build on Flushing and Mount Olivet Ave. Work will be done by day labor. Total estimated cost, $70,000.

N. Y., Brooklyn—The New York Congregational Home for the Aged, 123 Linden Ave., will install a steam heating system in the 3 story, 38 x 65 ft. hospital addition which it plans to build. Total estimated cost, $65,000. Parfit Bros., 26 Court St., Engr.

N. Y., Brooklyn—The State Hospital Commission, Capitol, Albany, received bids for the installation of a new engine and generator at the Brooklyn State Hospital, here, from T. F. Jackson, 99 John St., New York City, $9,187; G. E. Engineering Co., Laith & Varrick St., New York City, $9,750; Jandous Electric Equipment Co., 109 West 31st St., New York City, $9,770.

N. Y., Falconer—The Merriam Cabinet Co. plans to remodel the Chatauqua Planing Mills and install electric power units. Total estimated cost, $60,000.

N. Y., Flushing—The Board of Education, 500 Park Ave., New York City, will install a steam heating system in the 3 story school which it plans to build on Jamaica Road. Total estimated cost, $300,000. C. B. J. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Little Falls—The Barnet Leather Co., 598 East Mill St., plans to build a 3 story addition to its plant. Power units will be installed in same. Total estimated cost, $65,000. E. L. White, Supt.

N. Y., New York—The Cudahy Packing Co., 454 West 14th St., will receive bids about August 8 for the construction of a 2 story addition to its packing house at 611 West 34th St. A steam heating system will be installed in same. Total estimated cost, $50,000.

N. Y., New York—St. Mary's Free Hospital, 407 West 34th St., will receive bids until August 1 for the construction of a 5 story, 40 x 50 x 100 ft. Nurses' Home. A steam heating system will be installed in same. Total estimated cost, $75,000. C. P. H. Gilbert, 1123 Broadway, Engr.

N. Y., Syracuse—The Board of Education of Onondaga Valley plans to construct a 2 story, 150 x 200 ft. school here. Separate bids are desired for installing heating system and fan system of ventilating. Total estimated cost, $350,000. Ford, Buck & Sheldon, 60 Prospect St., Hartford, Conn., Engr.

N. Y., Watertown—The Northern New York Utilities, Inc., Light & Power Bldg., is having surveys made and plans prepared for the construction of a steel tower high tension transmission line from here to the Black River. H. G. Davis, Ch. Engr.

N. J., Bayonne—The Board of Education will receive bids until September 4, for the construction of a 4 story brick school on Avenue C. A steam heating system will be installed in same. Total estimated cost, $200,000. Donald Anderson, Bayonne, Arch.

N. J., Trenton—The Thermoid Rubber Co., Whitehead Rd., will install a steam heating system in the 3 story, 100 x 270 ft. plant which it plans to build. Total estimated cost, $150,000. Osborn Engineering Co., 2848 Prospect Ave., Cleveland, Ohio, Engr.

Pa., Duryea—The Universal Industrial Corporation plans to build a 1 story, 52 x 130 ft. silk mill with a 30 x 40 ft. wing. A steam heating system will be installed in same. E. H. Davis and G. M. D. Lewis, Union Bank Bldg., Scranton, Arch.

Pa., Oliphant—The Scranton Gas & Water Co. will install a steam heating system in the 1 story, 25 x 50 ft. office building which it plans to build. E. Davis and A. M. Lewis, Union Trust Bldg., Scranton, Arch.

Pa., Plymouth—The Congregation of St. Leo's Polish Catholic Church will install a steam heating system, including capital boilers in the 2 story, 50 x 133 ft. church which it plans to build. Total estimated cost, $90,000. Moms & McKale, Burr Bldg., Scranton, Arch.

Pa., Scranton—The Maccar Truck Co. will build a 1 story, 45 x 70 ft. power plant on Mulberry Ave. Total estimated cost, $60,000. Dans & Lewis, Union Bank Bldg., Arch.

S. C., Lake City—The city will receive bids about August 20 for the construction of a waterworks system, including steel tank and tower, deep well pumping machinery, boiler, etc. Total estimated cost, $90,000. Tomlinson Engineering Co., 1003 Loan & Exchange Bank Bldg., Columbia, Engr.

Ga., Columbus—The Bibb Manufacturing Co. plans to construct a transformer house in connection with the cotton weave shed which it plans to build. Robert & Co., Chandler Bldg., Atlanta, Engr.

Ohio, Ashland—The Ashland Tire & Rubber Co. will install a steam heating system in the 2 story, 75 x 125 ft. plant which it plans to build here. Total estimated cost, $90,000. Osborn Engineering Co., 2848 Prospect Ave., Cleveland, Engr.

Ohio, Ashland—The Faultless Rubber Co. will install a steam heating system in the 3 story, 80 x 160 ft. factory addition which it plans to build. Osborn Engineering Co., 2848 Prospect Ave., Cleveland, Engr. Total estimated cost, $75,000.

Ohio, Cleveland—The Chandler Motor Car Co., East 131st St. and St. Clair Ave., will install a steam heating system in the 3 story, 80 x 400 ft. machine shop addition which it plans to build. Total estimated cost, $200,000.

Ohio, Cleveland—The Hellanic Orthodox Community, West 14th St., will install a steam heating system in the 2 story, 46 x 85 ft. church which it plans to build at 2167 West 14th St. Total estimated cost, $75,000.

Ohio, Cleveland—The Jordon Motor Car Co., 1057 East 152nd St., will install a steam heating system in the 2 story, 97 x 167 ft. factory addition which it plans to build. Total estimated cost, $75,000.

Ohio, Cleveland—The Joseph Laronge Co., 214 Williamson Bldg., will install a steam heating system in the 12 story, 225 x 230 ft. theatre and office which it plans to build on East 17th St. and Euclid Ave. Total estimated cost, $2,500,000.

Ohio, Cleveland—Benjamin Moore & Co., 1314 Marquette Ave., plans to build a 4 story, 60 x 100 ft. factory on East 71st St. and Grant Ave. A steam heating system will be installed in same. Total estimated cost, $60,000. Architect not selected.

Ohio, Cleveland—Sommer Adams Co., 2934 East 55th St., plans to build a 2 story, 60 x 100 ft. power house and factory and will install a steam heating system in same. Estimated cost, $75,000.

Ind., Whiting—The Owl Club will install a steam heating system in the 5 story, 45 x 65 ft. club building which it plans to build. Total estimated cost, $65,000. Zimmerman, Saxe & Zimmerman, 64 East Van Buren St., Chicago, Arch.

Mich., Detroit—The Board of Education received bids for installing a heating and ventilating system in the 2 story addition to the A. L. Holmes School, Georgia and Crane Ave., from Ernst Bros. Co., 35 Bagg St., $57,040. John O'Connor, Penobscot Bldg., $57,988; James W. Partlan, 51 Park Pl., $59,400.

Mich., Detroit—The Fruehauf Trailer Co., 1371 Gratiot Ave., will install a steam heating system and electric motors to supply power in the 2 story, 100 x 260 ft. factory which it plans to build along the tracks of the Detroit Terminal R. R. near Deyninder St. Total estimated cost, $100,000. Stahl & Kinsey, McKerchey Bldg., Arch.

Ill., Chicago—The Century Rubber Works, 1346 Rawson St., will install a steam heating system in the 3 story, 200 x 350 ft. factory which it plans to build on La Salle St. Total estimated cost, $200,000. Osborn Engineering Co., 2848 Prospect Ave., Cleveland, Ohio, Engr.

Ill., Chicago—Lubiner & Trinz, 25 East Jackson Blvd., will install a steam heating system in the 2 story, 125 x 215 ft. theatre which it plans to build on Kedzie and Madison St. Total estimated cost, $500,000. W. W. Ahlschlager, 111 West Washington St., Arch.

Wis., Peshtigo—The Peshtigo Pulp & Paper Co. will install a steam heating system in the 2 story, 70 x 178 ft. factory which it plans to build on Main St. Total estimated cost, $55,000. Address J. A. Kittle, Peshtigo, Pres.

Kan., Harper—The city has engaged W. B. Rollins & Co., Engr., 209 Railway Exchange, Kansas City, Mo., to prepare plans for the construction of a waterworks system, including pumping equipment, engine, generator and pipe lines. Total estimated cost, $35,000.

Kan., Hudson—The city is having plans prepared by W. B. Rollins & Co., Engr., 209 Railway Exchange Bldg., Kansas City, Mo., for the construction of a transmission line for electric plant. Estimated cost, $15,000.

Kan., Hutchinson—R. E. Johnson will install a steam heating system in the 1 story theatre, which he plans to build here. Total estimated cost, $100,000. W. E. Hulse & Co., Hutchinson, Arch.

Kan., Manhattan—The Rocky Ford Milling & Power Co. is having plans prepared for a 2 story building and will install a 7000 hp. steam engine and 3000 kw. and 2000 k.w. turbines. Total estimated cost, $500,000.

Kan., Sharon Springs—The city will soon award the contract for the construction of a brick power house and the installation of 2 motor driven pumps and 1 or 2 oil engines with generators. Black & Veatch, Interstate Bldg., Kansas City, Mo., Engr.

S. D., Sioux Falls—The Board of Education will soon award the contract for the construction of a 2 story, 65 x 130 ft. school. A steam heating system will be installed in same. Total estimated cost, $100,000. Holmes & Flinn, 8 South Dearborn St., Chicago, Ill., Arch.

N. M., Socorro—E. T. Brown, Secy. and Treas. of the New Mexico State School of Mines, will soon award the contract for installing new heating plants in the School of Mines buildings, here.

Utah, Salt Lake County—The Davis County Irrigation Co. will build a pumping plant to irrigate 5000 acres. Estimated cost, $25,000. J. T. Hatch, Pres.

Ore., Condon—The County Court of Gillian Co. will soon award the contract for the installation of a vapor heating system in the courthouse. J. E. Schroeder, City Clk.

Ore., Pendleton—The School Board of District No. 16, 111 East Court St., will soon award the contract for the installation of a furnace hot blast or steam heating system, etc., in Hawthorne School. Estimated cost, $5000. R. W. Hatch, Despain Bldg., Arch.

Cal., Palo Alto.—The Board of Public Works received bids for furnishing and installing Deisel engine at the Municipal power plant, from McIntosh-Seymour Corporation, 461 Market St., San Francisco, at $48,900; electric generating unit, from the General Electric Co., Rialto Bldg., San Francisco, at $5680.

Ont., London—The Dominion Government, Ottawa, is having plans prepared by the Department of Public Works for the construction of a 3 story post office and customs building. A steam heating system will be installed in same. Total estimated cost, $400,000.

Ont., London—C. S. Hyman Co., Ltd., will soon award the contract for the construction of a 5 story, 150 x 300 ft. tannery on St. George St. A steam heating system will be installed in same. Total estimated cost, $300,000. H. C. McBride, Molsons Bank, Arch.

Ont., London—The McClary Manufacturing Co., 333 Wellington St., will install a steam heating system in the 5 story, 72 x 125 ft. addition which it plans to build to its factory on York St. Total estimated cost, $60,000. J. M. Moore, 425 Richmond St., Arch.

Ont., Victoria—The Town Council has appointed a committee to get estimates on hydro-electric power and lighting system for Charletteville Twp.

CONTRACTS AWARDED

N. Y., Brooklyn—E. Greenfield & Son, 95 Lorimer St., has awarded the contract for the construction of a 6 story, 40 x 100 ft. factory on Lorimer St. and Marcy Ave., to the Turner Construction Co., 242 Madison Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $80,000.

N. Y., Brooklyn—The Congregation of the Zion Norwegian Lutheran Church, 6301 5th St., has awarded the contract for the construction of a 1 story, 50 x 100 ft. church on 63rd St. and 4th Ave., to T. Drysdale, 250 Baltic St. A steam heating system will be installed in same. H. L. Otto, 21 Park Row, New York City, Engr.

N. Y., Central Islip—Lewis F. Pilcher, State Arch., Capitol, Albany, has awarded the contract for installing coal and ash handling equipment at the Central Islip State Hospital to the Guarantee Construction Co., 140 Cedar St., New York City. Estimated cost, $59,350.

N. Y., Cornell (East Freetown P. O.)—The Standard Oil Co., 26 Broadway, New York City, has awarded the contract for the construction of a 2 story, 46 x 52 ft. garage and office building, to H. D. Best, 949 Broadway, New York City. A steam heating system will b installed in same.

N. Y., Long Island City—B. Bleckman, 199 Lafayette St., New York City, has awarded the contract for the construction of a 6 story, 132 x 200 ft. factory, on Nott, Manby, Anable and Mount St., to Levening & Garrigue, 552 West 23rd St., New York City. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. Y., Long Island City—The Tidewater Oil Co., 11 Broadway, New York City, has awarded the contract for the construction of a 2 story, 30 x 140 ft. warehouse on Greenpoint Ave. and Newtown Creek, to H. D. Best, 949 Broadway, New York City. A steam heating system will be installed in same.

N. Y., New York—R. T. Crane, Jr., 1550 Lake Shore Drive, Chicago, has awarded the contract for the construction of a 4-story reinforced concrete warehouse at 1996-2010 Park Ave., to the White Construction Co., 95 Madison Ave. A steam heating system will be installed in same. Total estimated cost, $175,000.

N. Y., Potsdam—T. E. Finegan, Deputy Comr. of Education, Education Bldg., Albany, has awarded the general contract for the construction of a new boiler house at the Potsdam Normal School, to H. M. Weed, 200 5th Ave., New York City, $42,300, heating work, to H. J. Brandeles, 431 Lafayette St., Utica, $36,000. Noted July 22.

N. J., Jersey City—The city has let the contract for the construction of Public School No. 23 on Central Ave., to Michael T. Connelly, 238 17th St. A steam heating system will be installed in same. Total estimated cost, $643,000.

Ohio, Cleveland—The National Lamp Co., Nela Park, has awarded the contract for the construction of a 3 story, 80 x 110 ft. factory, to Sam W. Emerson Co., 1900 Euclid Ave., Cleveland. A steam heating system will be installed in same. Total estimated cost. $200,000.

Ill., Columbia—The village has awarded the contract for the construction of a light and power plant, to Baumes-McDevitt Machinery Co., Railway Exchange Bldg., St. Louis, Mo. A 100 hp. H. R. T. boiler and breeching, 100 ft. x 4 inch concrete chimney, 120 hp. non-releasing Corlis or Unaflow engine and heaters will be installed in same. Total estimated cost, $100,000.

Minn., Austin—The city has awarded the contract for installing a boiler at the municipal electrical plant, to Babcock & Wilcox Co., Chicago, $12,177, stoker, to Robinson, Carey & Sands, 4th and Wacouta St., St. Paul, $7440.

Minn., Minneapolis—The State Board of Control, Capitol, St. Paul, has awarded the contract for installing new generating units for the electric light plant, to J. W. Hildred Co., 33 East 3rd St., St. Paul, an engine at $5,980 and a refrigerating plant at $9920, to the General Electric Co., 410 3rd Ave., a generator at $3,035. Noted July 1.

Mo., St. Joseph—The St. Joseph Railway Light, Heat & Power Co., has awarded the contract for the construction of two 225 ft. stacks, one 16 ft. and the other 12 ft. in diameter, to the Kansas City Structural Steel Co., 705 Orear Leslie Bldg., Kansas City, 110 tons structural under framing, 31 tons breeching and 86 tons reinforcing, to the Structural Steel Co., Kansas City. All awarded on tonnage basis. Noted July 1.

N. M., Magdalena—The H. W. Light & Power Co. has awarded the contract for the construction of a 51 x 101 ft. light and power plant and ice plant, to Osborn & Catalano, Magdalena, $13,000.

Cal., Los Angeles—The Board of Education, Security Bldg., has awarded the contract for installing a steam heating system in the school which it plans to build on East 7th St., to Arthur Hess, Baker-Detwiler Bldg. Estimated cost, $8923.

N. B., Presque Isle—The Maine & New Brunswick Power Co. has awarded the contract for enlarging dam and power house and installing 1875 k.v.a. unit in its present plant, to the Foundation Co., Montreal, Que. Estimated cost, $125,000.

N. B., Marysville—The Nashwaak Pulp & Paper Co., Ltd., has awarded the contract for a dam and water power development, to the Ambursen Hydraulic Construction Co. of Canada, Ltd., New Birks Bldg., Montreal, Que.

"SEARCHLIGHT" Clippings:

For "Opportunities" — THINK "SEARCHLIGHT" FIRST! See pages 83 to 93

PRICES - MATERIALS - SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		70c. per ft.
Common, 2½-in.		40–10%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.45	$0.30	$0.20

Steam—Discounts from List

First grade..... 35% Second grade..... 45% Third grade....50%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 65% Best grade..... 40%
Standard..... 50–10%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	45%	35%
St. Louis	45%	35%
Chicago	45%	40%
Birmingham	30%	35%
Denver	35–5%	10%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.50
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.10
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List

For low-pressure heating and return lines { 4-ply..... 58% off; 3-ply..... 60% off; 2-ply..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5½	7	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	8½	20
Axle	4½	6	4	4.75	4	5½
Gear	4½	9	4½	7.5	8½	8
Car journal	22(gal.)	21 (gal.)	3½	4.9	8½	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11.00 to 13.00	13.00	14.00	11.00 to 14.00
Colored mixed	8.50 to 12.00	12.00	11.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$52.00	$58.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Cleveland	Chicago	
	Current	One Year Ago	Current	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$2.15	$1.86	$2.15	$2.48	$2.53
5-gal. cans	2.28	1.96	2.40	2.68	2.73

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	13.00	14.50	14.00	14.50	13.00	14.00
25- and 50-lb. kegs	13.25	14.75	14.25	12.75	13.25	14.25
12½-lb. keg	13.50	15.00	14.50	15.00	13.50	14.50
1-lb. cans	16.00	17.50	.....	.....	16.00	17.00
5-lb. cans	15.00	16.50	.....	.....	15.00	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	65%	60–5%	45%
Tinned	65%	60–5%	40%

Boiler rivets, ½, ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York....$6.35 Cleveland...$4.00 Chicago...$4.87 Pittsburgh...$4.65

Structual rivets, same sizes:

New York....$6.25 Cleveland...$4.10 Chicago...$4.97 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$90–100	at Chester, Penn.
Chrome cement	net ton	45–50	at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35–45	at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30–35	at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50	at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90	at Chester, Penn.
Silica brick	net ton	41–45	at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $30 to $40.
Birmingham—Fire clay, $41–$44; silica, $46.50–$54.50; magnesite, $80-$85; chrome, $80-$90.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL—Domestic light, 22-26 deg., Baume, is 8½c. per gal. in St. Louis.

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	90.00	125.00	79.00	108.00	75.00	100.00
Commercial	50.00	70.00	17.50	23.00	15.00	24.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$21–26	$19.00
Cleveland	20.00	20.00
Chicago	16.50	19.00

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 15c. per lb.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Inches	Steel Black	Steel Galvanized	Inches	Iron Black	Iron Galvanized
⅛, ¼, and ⅜	50½%	24%	⅛ to 1¼	39½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

2	50½%	38%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	46½%	29%	½ to 1¼	39½%	24½%
½	51½%	39%			
¾ to 1¼	55½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48%	37½%	2	33½%	20½%
2½ to 4	51%	40½%	2½ to 4	35½%	23½%
4½ to 6	50%	39½%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York Black	New York Galvanized	Cleveland Black	Cleveland Galvanized	Chicago Black	Chicago Galvanized
⅛ to 3 in. steel butt welded	47%	31%	43½%	34½%	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	45½%	20½%	53½%	41%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%.
Cast iron, standard sizes, 10% off.

BOILER TUBES—The following are the prices for carload lots, f. o. b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	40½	3½ to 4½ in.	15½
2½ to 3¼ in.	30½	3 to 3¼ in.	1
2¼ in.	24	2½ to 2¾ in.	+ 1
1¾ to 2 in.	19½	2 to 2⅛ in.	+16
		1¾ to 1⅞ in.	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$327	1¼ in.	$207
1¼ in.	267	2 to 2½ in.	177
1½ in.	257	2¾ to 3¼ in.	167
1¾ in.	207	4 in.	187
		4½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	285.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready

	Each, Net
Less than 12	$0.40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanised 100 and Over	Black 100 and Over	Galvanised 100 and Over
⅜	$71.15	$76.25	$17.04	$18.18	$5.38	$5.74
½	71.15	76.25	17.04	18.18	6.28	6.70
¾	93.96	100.86	22.43	23.93	8.97	9.57
1	138.39	149.09	33.19	35.41	11.66	12.44
1¼	187.91	201.71	42.62	45.31	16.10	17.12
1½	224.68	241.18	56.82	60.62	19.89	21.15
2	302.29	324.49	104.17	110.77	26.52	28.20
2½	477.95	513.05	170.46	181.26	37.88	40.28
3	625.00	670.91	454.56	483.36	56.82	60.42
3½	779.24	834.44	1,003.82	1,067.42	75.76	80.56
4	945.03	1,010.43	1,160.08	1,233.57	94.70	100.70

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ⅜ in., 100 ft. Standard lengths flexible, ½ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size	I. D., In.	Feet per Coil	List, Ft.	
⅜		250	$0.05½	Coils....55% off
½		250	.06	Less coils, 46% off
¾		250	.09	
¾		200	.12	
¾		200	.15	
¾		150	.18	
1		100	.25	
1¼		100	.33	
1½		Odd lengths	.40	
2		Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T. P. S. B.	.81	1.80	....
D. P. D. B.	.78	2.10	....
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$16.75
No. 16 cotton twisted	22.00
No. 18 cotton parallel	19.80
No. 16 cotton parallel	25.75
No. 18 cotton reinforced heavy	30.00
No. 16 cotton reinforced heavy	36.50
No. 18 cotton reinforced light	23.40
No. 16 cotton reinforced light	27.50
No. 18 cotton Canvasite cord	26.00
No. 16 cotton Canvasite cord	28.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
450-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 30%
1-5th to standard package 40%
Standard package 52%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75 C
0-30 ampere, less than standard package	6.00 C

LAMPS—Below are present quotations in less than standard package quantities.

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B— Watts	Plain	Frosted	No. in Package	Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.00	$14.00	$13.90	$25.00
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	....
0000	.....	.....	288.60	...

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$15.00	$16.00	$34.00	$16.00	$21.00	$33.00	$11.50	$15.25	$30.33
10	17.65	24.25	48.00	27.20	31.00	69.00	33.81	24.25	55.08
8	24.50	31.75	66.00	38.00	42.00	78.00	47.02	32.60	74.61
6	38.65	42.25	.....	.....	65.00	130.00	65.94	54.75	...
4	54.35	58.95	.....	.....	93.00	.....	91.70	73.75	...
2	80.85	86.15	.....	.....	140.00	.....	130.97	104.50	....
1	100.05	113.10	.....	.....	182.00	.....	172.38	136.40	....
0	.....	158.00	.....	.....	242.00	.....	204.51	174.60	....
00	.....	183.60	.....	.....	290.00	.....	251.94	214.00	....
000	.....	222.80	.....	.....	360.00	.....	306.1	257.50	....
0000	.....	269.70	.....	.....	435.00	.....	371.38	308.50	...

Pittsburg—23c. base; discount 50%

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap.			¼ In. Cap		
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package +20%
1-5th to standard package +10%
Standard package −15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	36c. lb
No. 18 B.&S. regular 1-lb. coils	37c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.120
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.3
200	4.40	6.76	10 14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%